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TABLE OF CONTENTS:

ENGINEERING NEWS OF THE WEEK..... 129, 135
Electric Percussion Rock Drills (illustrated)..... 130
Instructions for Installing Weirs, Measuring Flumes and Water Registers (illustrated)..... 131
Fixing Responsibility for the Fall of a Concrete-Iron Footbridge at the Paris Exposition..... 135
The Danger of Electric Light and Trolley Wires to Firemen When Fighting Fires..... 135
The Accidents at the East Side Water-Works Intake Tunnel, Cleveland, O. (illustrated)..... 138
Review of Marine Engineering During the Last Ten Years (with two-page plate and other illustrations) 139
Annual Convention of the League of American Municipalities..... 144
EDITORIAL NOTES..... 136
The Hudson River Bridge—Traffic on the Manchester Ship Canal—Investigation of Smoke Prevention by the Mutual Boiler Insurance Companies—The Effect on Steel of Small Percentages of Copper.
EDITORIAL:
Recent Practice in Electric Railway Construction and Operation..... 126

THE YELLOW FEVER RECORD in Havana for the month of July shows only four cases and one death, the lowest record ever made in July. We quote as follows from the monthly report of Major W. C. Gorgas, Chief Sanitary Officer, dated Nov 6:

The yellow fever year commences April 1. In the four months, April to July, inclusive, the maximum number of deaths from yellow fever occurred in 1897, with 501 deaths; the minimum, in 1899, with 5 deaths. This year we had one death; that is, we have passed one-third of the year in Havana, including July, which is generally one of the severe months for yellow fever, with only one death; and this one death would never before this time have been considered due to yellow fever. It was reported by the physician in charge as "borras."

During the month six known cases were introduced into the city from Santiago de las Vegas, a little town of 6,120 population, situated on the railroad 20 km. from Havana. In accordance with the directions of the Adjutant-General, a considerable force was put into Santiago de las Vegas, and work at once commenced in an endeavor to free the town from infection. Our efforts were made entirely in the line of destroying infected mosquitoes. I begin to feel pretty confident that by our present methods of disinfection we can eliminate infection after it has gotten in. I am inclined to think that we have done so at present. We have had no cases originating in the city since July 24, and with 30,000 non-immunes scattered in every part of the city, I am sure that we would have had more cases unless the infection had been killed, particularly as it is the month of August, when usually the disease is in full blast.

Most of the time of the departmtnt is now turned to the destruction of the mosquito, both in the attempt to kill all infected mosquitoes in the neighborhood of each focus of infection as it appears, and generally about the city, to destroy the larvæ and drain their breeding places.

THE MASONRY DRY-DOCK for the Brooklyn Navy Yard will soon be advertised for construction. The new dock is to have a depth of 30 ft., and will be built of stone masonry and have every facility for docking the largest ships. Plans have also been drawn for the construction of a stone masonry dock larger than the proposed New York dock, at the new naval station at Charleston, S. C., to take the place of the dock at Port Royal. The necessary land at Charleston has been acquired and the specifications for the work will soon be completed. The cost of these docks will be over $1,000,000 apiece.

AN ELECTRIC POWER PLANT and street railway consolidation scheme of large proportions is reported to be contemplated at Omaha, Neb. According to the reports, the plan first contemplates the union of several large interests in the cities of Omaha, South Omaha and Fremont, Neb., and Council Bluffs, Ia. The companies comprised in the proposed consolidation are the Omaha St. Ry. Co., which operates the electric lines in Omaha, South Omaha, Dundee and Benson; the Omaha & Council Bluffs St. Ry. & Bridge Co., which owns and operates the electric lines of Council Bluffs, and from that city to Lake Manawa, and also the big draw bridge across the Missouri River; the Suburban Ry. Co., which owns an electric line between Omaha and Council Bluffs and the bridge spanning the Missouri, known as the East Omaha bridge; the Council Bluffs Electric Light Co., the New Omaha Thompson-Houston Electric Light Co., holding the franchises of Omaha and South Omaha; the Fremont St. Ry. Co., the Omaha Water Co. and the Council Bluffs Water Co. All of these corporations have, it is stated, consented to the consolidation except the Omaha Water Co. Aside from these companies, certain promoters are seeking a franchise for an electric road between Omaha and Fremont, a distance of 35 miles, which is to be included in the consolidation. The second object of the consolidation will be the establishment of a large electric power plant. The power is to be obtained by the construction of a dam about four miles south of Fremont, Neb., between the bluffs of a small stream, which is an offshoot of the Platte River, returning its waters to the Platte at the point where the engineers have located the site of the dam. The dam itself will cost approximately $3,500,000. It will be but 25 ft. wide at its base, but 1,260 ft. across at the top, which will lie about 30 ft. above the peak of the bluffs. The dam will have a wall of cement, with an outer covering of dirt, the face of the dam itself being of masonry. Above the dam will be erected the generating plant, which will create the electric power from the fall of 157 ft. obtained by the construction of the dam, and will send the electric current generated over wires to Omaha, less than 28 miles away. The cost of this plant, together with the receiving and distributing plant to be constructed at Omaha, is, according to the plans already drawn, to be approximately $1,250,000. The power derived from the plant will, according to the engineers' figures, be equal to 30,000 HP. for 24 hours a day, or 50,000 HP. for 10 hours a day. This power is to be used for the purposes of the consolidated street railway and electric lines, the suburban lines out of Omaha and Council Bluffs, the electric lighting systems of the four cities concerned, and for the uses of manufacturing plants in these four cities and intervening points.

BLUESTONE SIDEWALK SLABS of unusual dimensions are being laid in front of the Prudential Insurance Building, now under construction at the corner of Bank and Broad Sts., Newark, N. J. On the Broad St. front the pavement will be 108 ft. in length and along Bank St. 264 ft. For the entire distance, 374 ft., only 35 stones will be used. The largest will be 12 ft. wide and 21 ft. 7 ins. in length. The length of the longest stone will be 22 ft. 1 in., and the widest will be 12 ft. in breadth. All of these will be on the Broad St. front. On the Bank St. side the surface proportions of the largest stone will be 12 by 17 ft., and the smallest will be 11 ft. long and 10 ft. wide. There will be 10 stones on Broad St. and 25 on Bank St. The stones on Broad St. will be 8 ins. thick and the others 6 ins. All of the stones are from the quarries of the Newark Bluestone Co., at Pond's Eddy, Pike county, Pa. As there has never before been a call for stones of such large dimensions, it was necessary to build a 35-ton machine for the purpose of planing down the huge blocks and putting them into shape for use as paving stones. This planer is said to be the largest in existence, and is capable of handling a block 25 ft. long and 14 ft. wide. Seventeen stones have thus far been received from the quarry, and 14 of these have been dressed for use.

CONCRETE SIDEWALKS are required in Wheaton, Ill., under an ordinance recently passed. This provides that the ground shall be excavated to form a sub-grade 13 ins. below the pavement level, the surface to be compacted and then covered with 10 ins. of clean gravel or cinders. Upon this bed will be laid a 3-in. course of concrete, composed of 1 part Portland cement, 2 parts sand and (after the cement and sand have been mixed dry) 5 parts broken stone not exceeding 2½ ins. in greatest dimensions. Clean water will then be added in sufficient quantity to give a surplus of moisture when rammed. Upon this will be a finishing coat composed of 1 part imported Portland cement and 1 part torpedo gravel. The concrete and finishing coat will be laid in alternating sections, 5 ft. in length and 5 ft. apart, the alternate sections to be filled in after the first ones have set. The walks must be at least 4 ft. wide, with a slope towards the curb of 1 in 36. The ordinance permits the use of sidewalk brick or stone laid on the cinders or gravel instead of concrete. No other construction will be allowed, under penalty.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a head-on collision on the Chicago & Alton R. R., near Prentice, Ill., on Aug. 21, in which five persons were killed and six others badly injured. The dead are the engineer and fireman of the passenger train and three unknown men, who were riding on the tender. Just how the accident occurred is not known. The freight train had pulled into a siding from the west end to await the passenger train. It is supposed the train gradually worked out over the switch, unobserved by the crew, and when the passenger train came along at a high speed it struck the portion which fouled the main track. Both engines were demolished, while the tender of the passenger engine telescoped the smoking car, which rolled over.

AN EXPLOSION OF DYNAMITE wrecked a freight train on the Southern Pacific R. R., near Glendale, Cal., on Aug. 17. According to the press dispatches an extra freight train, composed of 26 cars, with three engines, was just emerging from tunnel No. 7, 6½ miles north of Glendale, which is a short one, on a sharp curve in the track about 100 ft. long, when the train parted, the air hose breaking and the sudden jar causing the dynamite in the rear two cars to explode. The entire train was destroyed, except one engine, and it was damaged somewhat. There were ten cars of melons, two of powder, two of fruit and the remainder of miscellaneous cargoes. The explosion was felt for miles around. A car filled with acid took fire and the flames spread to the dry brush and timber, causing a fierce conflagration. The buildings of the Victory mine, a half-mile distant, were badly shattered. The train crew escaped with only a few bruises and scratches. At least eleven cars were blown to atoms and cannot be accounted for, even their trucks being missing. The tunnel appears not to have been damaged, though the track and roadbed were torn up for a great distance.

SERIOUS TROLLEY CAR ACCIDENTS are reported from a number of places. At Gloucester City, N. J., a train on the Camden, Gloucester & Mt. Ephraim R. R. ran full speed into a trolley car and killed one person, fatally injured two and seriously hurt 12 others, all passengers of the trolley car. According to the press dispatches the accident happened at the corner of Broadway and King St., where the tracks of these two lines cross, and where there are no safety gates. The engine struck the car a glancing blow that cut off the end of the car and hurled it some feet away, while the other part of the car was jammed into a telephone pole beside the trolley tracks. At Atlanta, Ga., a head-end collision on the River line of the Rapid Transit Co., on Aug. 23, killed one man and injured 17 people, three of them seriously. The collision occurred on a sharp curve. Both cars were running at full speed, and they came together so suddenly on rounding the curve that there was no chance to check the momentum or opportunity for the passengers to jump. It is understood that one of the cars was behind time and was attempting to make a switch which it should have reached had it maintained its schedule.

THE BROOKLYN COLLISION of Aug. 17, noted last week, has been investigated by the New York Railroad Commission, which finds that the track where the collision occurred was protected by a model interlocking plant, in good condition, and that the accident was due to the motorman of the electric car disregarding the signal, which was set against him. The Commission recommends that derailing switches interlocked with the signals and operated from the towers be added to the plant.

THE COLLAPSE OF A BRIDGE SPAN under erection at Pittsburg, Pa., on Aug. 15, caused considerable damage, and the wreck of an approaching passenger train was narrowly averted. The span was 120 ft. long and was a part of the new bridge from Fleming Park to Neville Island. According to the press dispatches, the collapse was caused by the falseworks being torn away by a projecting fly-wheel carried on a flat car of a freight train which was passing underneath the new structure. The fast express for Cleveland, O., which was due at the time of the accident was stopped within 150 ft. of the debris.

FLY-WHEEL INSURANCE has just been established as a department of one of the largest companies writing insurance against casualties. The policy will cover all damages to persons or property caused by the breaking of fly-wheels or large pulleys, whether the property be that of the policy holder or that of some third party for the damage to which he is liable. The company will not only insure, but will inspect the wheel before writing the policy, and repeat the inspection at regular intervals. In view of the large number of fly-wheel disasters which occur nowadays, and the large casualties which frequently accompany them, such insurance and inspection should be welcomed by manufacturers and others using steam engines.

THE THIRD TRIAL OF MOTOR VEHICLES for heavy traffic, conducted by the Liverpool Self-Propelled Traffic Association, has resulted in the award of gold medals to the following vehicles in each of the four classes:

Class A: Load, 1½ tons; maximum tare, 2 tons; minimum level platform area, 45 sq ft.; minimum width of driving tires, 3 ins.; speed, 8 miles per hour. Geo. F. Milnes & Co., Ltd., Motor Department, "Motoria," 17 Balderton St., Oxford Street, London.

Class B: Load, 5 tons; maximum tare, 3 tons; minimum level platform area, 75 sq. ft.; minimum width of driving tires, 5 ins.; speed, 5 miles per hour. The Lancashire Steam Motor Co., Leyland, near Preston.

Class C: Minimum load, 5 tons; no tare limit; minimum level platform area, 95 sq. ft.; minimum width of driving tires, 6 ins.; speed, 5 miles per hour. The Thornycroft Steam Wagon Co., Ltd., Chiswick and Basingstoke.

Class D: Minimum load, 4 tons; no tare limit; level platform area not specified; minimum width of driving tires, 4 ins.; speed, 5 miles per hour. The Thornycroft Steam Wagon Co., Ltd., and T. Coulthard & Co., Ltd., Cooper Road, Preston.

The silver medal of the Association was awarded to the Mann Patent Steam Cart & Wagon Co., Ltd., Canning Works, Dewsbury Road, Leeds. In announcing the awards the committee of experts states:

We have confidence in recommending the vehicles to which gold medals have been awarded for adoption where haulage of goods by mechanical means is contemplated. We also draw attention to the vehicle of the Lancashire Steam Motor Co., the performance of which, in respect of load and consumption, was highly creditable, whilst the tare was below the present legal limit of 3 tons. In Class D, the vehicles had several points in which they were practically equal and some in which each excelled the other. We, therefore, had no alternative, where each had high merits, but to award two gold medals in this class.

ELECTRIC PERCUSSION ROCK DRILLS.

While compressed air drills have hitherto been the type most generally used in mining work, various forms of electric drills have been devised from time to time, and some of these have been described and illustrated in our columns. The question of the application of electric power to the operation of drills was discussed in our issue of May 16, 1891, and it was shown that the cost of plant might be less than for compressed air drills, but that the great saving would be in the reduction of cost of drilling the holes. These machines would appear to be specially applicable for mining operations, where the work is permanent and extends over long distances, but they are perhaps less adapted for railway or other tunneling operations, which are of a more temporary character. In most of the early electric drills the reciprocating motion of the drill rod was obtained by surrounding the rod with two coils, one at each end of the drill casing, and energizing these coils alternately. In the present article, however, we describe two electric drills in which rotary motion is transmitted from a portable motor through a flexible shaft to a crank shaft in the drill casing, from which reciprocating motion is given to the drill rod by a bell crank in one case and a cam in the other. In a third machine, the motor is contained in the drill casing itself, and operates a hammer which strikes an ordinary cross-bit drill. All of these drills are in practical use in mining operations.

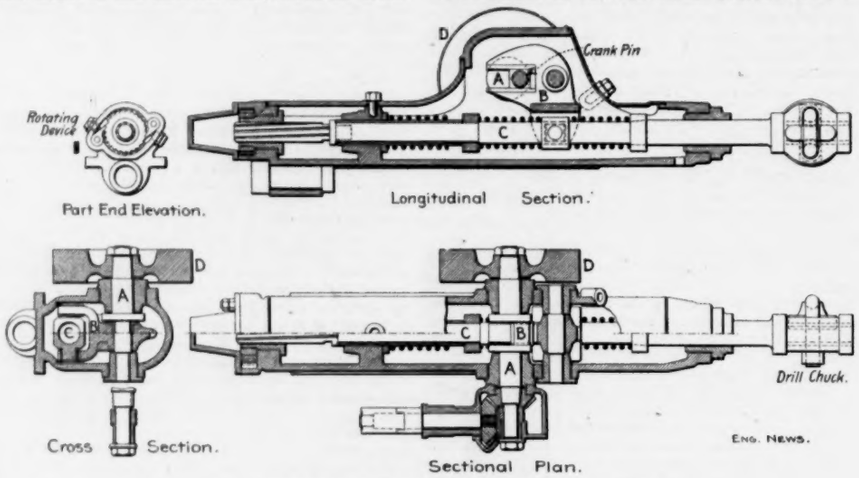


FIG. 1. SECTION OF THE DURKEE ELECTRIC DRILL.
Mine & Smelter Supply Co., Denver, Colo.; Makers.

THE DURKEE DRILL.—The Durkee drill, Fig. 1, is operated by a flexible shaft driven by a portable electric motor of 1½ HP. The shaft is attached to a bevel gear driving a crank shaft, A, which passes through the drill casing. The crank pin works in the slotted horizontal arm of the bell crank lever, B, which is mounted on a shaft journaled in the casing. The vertical arm straddles the drill rod, C, and is fitted to trunnions on a casting which slides on the rod. Between this casting and collars on the rod are coiled springs through which the power is transmitted for movement of the rod in each direction. The parts are so proportioned as to give a sharp cutting stroke and a slower return stroke, while a flywheel, D, on the crank shaft also provides for uniformity of action.

At the heel of the rod is a rifled section or ratchet rod working in a rifled nut by which the required rotary movement is given to the drill bit. The rotating device and the chuck are the same as in compressed air drills of the ordinary type, and the general design of the machine, apart from its special operating mechanism, follows closely upon that of air drills. The cylindrical casing is fitted to a slide or feed table operated by a feed screw and crank handle in the usual way, and this table is mounted either upon a column, tripod or bar, according to the requirements of the work.

The machine makes about 580 strokes per minute, and its weight, exclusive of the tripod or other support, is about 230 lbs. A number of the machines are now in use in mining operations, and they are being introduced by the Mine & Smelter Supply Co., of Denver, Colo.

THE GARDNER DRILL.—This is in several respects similar to the Durkee drill, and a view of the machine, mounted upon its tripod, is shown in Fig. 2. The drill is operated by an electric motor, the power of which is transmitted to the drill by a flexible shaft 8 ft. long, which allows the motor to be placed in any convenient position close to the drill. The regular safety fuse is placed in the circuit to protect the motor from damage, but experience has shown that the miners are very likely to be careless in replacing fuses, and, in some instances, are inclined to insert a piece of copper wire, or a nail in lieu of the fuse. To overcome this, the makers have introduced another safety device, called a slip friction gear. The motor ordinarily runs at 1,800 revolutions per minute, and is geared to the jack shaft by means of a phosphor bronze pinion and a cast-iron spur wheel. This wheel is loose on the shaft, and drives it by means of two fiber disks on either side of the hub, the pressure being produced by a spring which is set at sufficient tension to drive the drill under normal conditions, but should the drill steel stick in the rock and prevent rotation of the flexible shaft this cast-iron gear would slip, thus preventing serious damage to any part of the mechanism.

The power is transmitted from the flexible shaft to a pair of miter gears on the drill casing, one of which rotates the crank shaft, having a roller on the center crank pin. This crank shaft transmits power to what is termed a drawbar, in which is a cam slot, which gives the drawbar and piston a relatively quick forward motion and a slow return. This drawbar transmits power to the piston through spiral springs, which are of sufficient strength to strike the blow necessary to drill rock, while at the same time they are useful in forming a cushion if it is desirable to ream a hole, as the drill can be run without striking rock without damage to the machine. Owing to the special shape given to the cam slot, a quarter turn of the crank imparts the forward stroke to the piston; the succeeding half turn of the crank is employed in withdrawing the drill, while the last quarter turn imparts no movement to the drawbar.

On the crank shaft is a balance wheel geared up to a high speed, thus enabling a light flywheel to be used, at the same time reducing the weight of the drill. The rotation of the drill steel is effected by means of ratchet wheels located in the forward part of the body of the drill and surrounding the piston. In the piston are straight grooves which engage the corresponding ratchet wheel for guiding the piston straight during the forward stroke, and spiral grooves which engage the corresponding ratchet wheel for rotating the drill on its backward stroke. The steel is held in the chuck by a novel clamp with a single nut, it being only necessary to turn the nut one-quarter of a revolution to remove the bit. The main clamp of the drill is held by one bolt, and by loosening one nut the drill can be swiveled. A feature of the clamp is its side motion, by which means the drill body may be moved to one side sufficient to remove and replace the long steels, after which operation it is brought back and placed against a stop without losing the alinement of the hole.

The drill is made in two sizes, weighing 150 and 200 lbs., with 1½ and 2-HP. motors respectively. The smaller one strikes 600 blows per minute, with a 2½-in. stroke, and will drill to a depth of 5 ft. The larger one strikes 500 blows with a 3-in. stroke, and will drill holes 8 ft. deep. The speed of the motor is controlled readily by the operator. It is claimed that these machines can be installed at a cost about half that of ordinary air drills, and also that they will do as much work as air drills of equal weight with only one-tenth the power re-

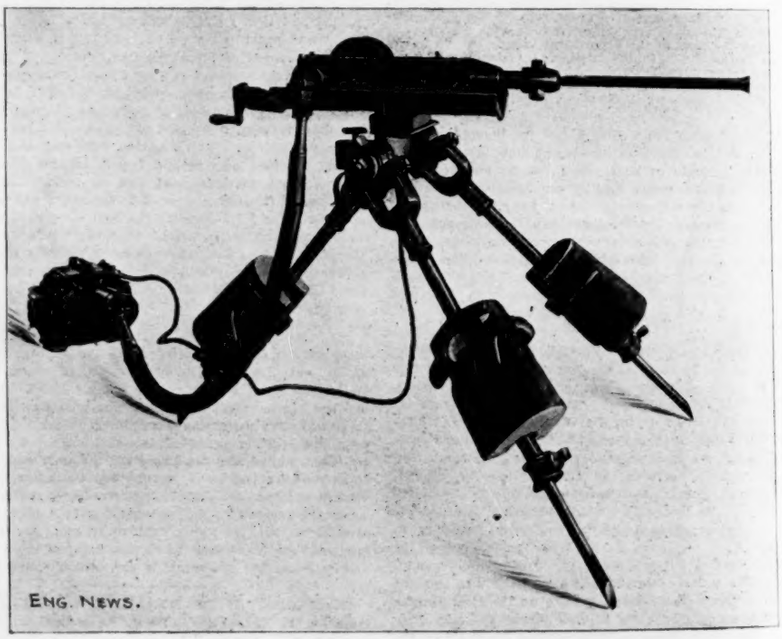


FIG. 2. THE GARDNER ELECTRIC DRILL.
Gardner Electric Drill & Machinery Co., Cleveland, O., Makers.

quired by the latter. The machine is being introduced by the Gardner Electric Drill & Machinery Co., of Cleveland, Ohio.

THE HERCULES DRILL.—The general appearance of this drill is shown in Fig. 3, where, however, the drill is tipped up for working in the "roof." The electric motor is contained within the casing, and drives a train of mechanism which operates a hammer in much the same way that it would be used by hand. The drill is fed

Fig. 3. The Hercules Electric Rock-Drill, Made by the Hercules Electric Drill Co., 32 Broadway, New York City.

by a feed screw at the back of the casing, and it may be mounted upon a column or bar, as well as in the manner shown in the cut.

The mechanism of the drill may be understood by referring to Fig. 4. The magnet frame of the motor is in one piece with the box-like casing of the machine. The armature (C) of the motor, by means of a pinion upon its shaft, drives the intermediate gear (D), which in turn drives the gear (E). The latter drives the shaft (S) by means of a disk friction clutch contained within itself, which acts as a safety device to prevent stalling the motor. Upon the shaft are two eccentrics standing at right angles to each other. The straps of these eccentrics are the parts lettered (G) and (F). These parts are perfectly free to turn about the shaft, except that the part (G) is attached by a link at (J) to the frame at (L), so that, when the shaft rotates, (G) will have an oscillating motion. Also, the part (F) is attached to (G) by the part (U), with pins at (X) and (V). The shaft rotates in a clockwise direction, and if the movement is followed out, it will be seen that the part (U) is given a swinging motion through an arc of about 90°, rising slowly and descending quickly. The time occupied by the downward stroke is about one-third that of the upward stroke. The part (U) carries two rollers (I) and (H) (only the holes for the axle of the latter are shown on the drawing), between which passes the hammer handle. The latter is of a peculiar curved form, and is pivoted at (K) upon the part (G). (In practice this handle is made solid, instead of being split, as shown on the drawing.) It will be seen that the part (U) in its up-and-down motion carries the hammer with it, causing the latter to deliver a blow each time upon the tool (T). At the moment when the hammer strikes the tool the handle does not touch either (I) or (H), so no severe shock is transmitted to the mechanism. In case there is no tool in the machine the handle strikes (H) while the latter is still on its downward course, and the force of the blow is taken up in accelerating the machine, and perhaps partly in slipping the clutch in (E).

We will now describe the mechanism for raising and turning the tool. The part (N) is hinged to the part (G) at (J). On its lower end it carries the part (Z), which engages the tool-holder (P). The latter is provided with spiral slots engaging the ratchet disks at (Q), and a straight slot in which slides an internal projection on the ratchet disk (R). At the same time that the hammer is rising, the part (N) lifts the tool-holder, and the ratchets at (Q) engage, and the holder is given a one-eighth turn. As the holder descends the ratchet at (R) engages, preventing the holder from turning back. This operation is timed so that the tool is firmly set when the hammer strikes it, and at that instant the spring (O) is in compression, thus bringing no shock directly upon (N). Overfeeding the machine results only in compressing this spring still more, until the tool is so high that the hammer cannot complete its swing, in which event the clutch in (E) will slip.

The motor is rated at 2 HP., and is capable of giving 200 blows per minute with a 7-lb. hammer. The force of the blow may be regulated by varying the speed of the motor. A member of the editorial staff of this journal witnessed one of these machines at work drilling in hard granite, and there was no vibration sufficient to interfere with the free movement of the drill in a 4-ft. hole. The complete machine with stand weighs less than 400 lbs.

This drill is being put upon the market by the Hercules Electric Drill Co., of 32 Broadway, New York city, to whom we are indebted for the drawing and photograph shown herewith.

INSTRUCTIONS FOR INSTALLING WEIRS, MEASURING FLUMES AND WATER REGISTERS.*

By Clarence T. Johnston, C. E.†

WEIRS.

Weirs are to be employed wherever the conditions will permit, and where not, a measuring flume is to be substituted. A Cippoletti weir is the form to be substituted. Fig. 1 shows its detail and the method of placing the recording instrument with sufficient clearness to permit of its proper construction. The following directions should be observed:

(1) The dimensions of the flume in which the water is placed will be governed by the volume of water to be measured, but in no case should the length be less than 16 ft., nor the width be less than the surface water line of the ditch. The bottom of the flume should be level in both directions. The upstream end should be placed on grade with the bottom of the ditch, so that the water will enter without eddies or disturbance. The channel of the ditch should have a uniform grade and cross-section for 100 ft. upstream from the flume, and its axis should pass through and be parallel to the middle of the structure.

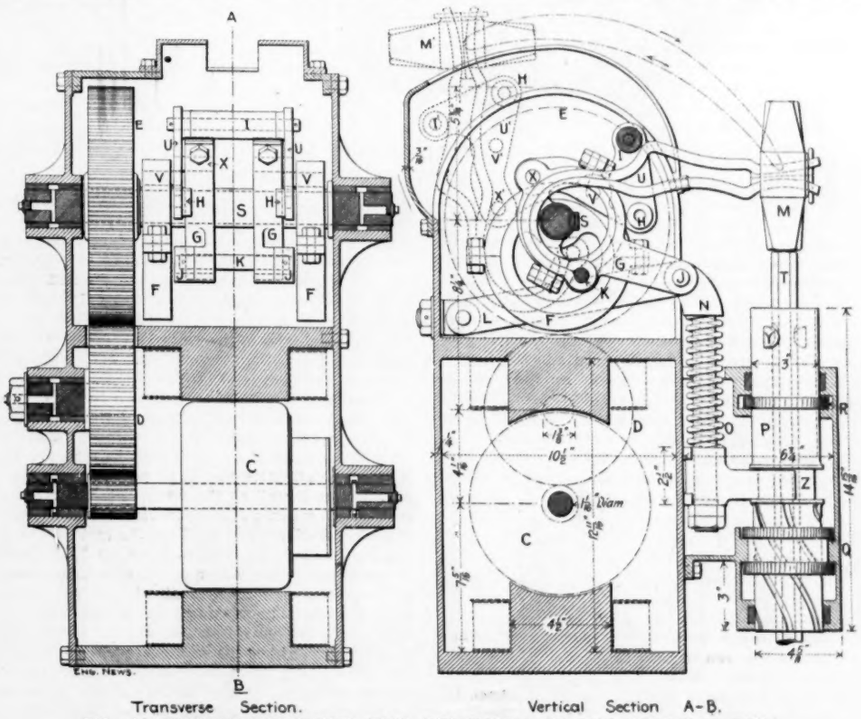
(2) The length of the weir should be sufficient to permit all the water needed to pass over it without the depth in any case exceeding 2 ft.

(3) The end and bottom contractions of the weir must be complete. To secure this (a) the crest of the weir must be horizontal; and the sides must be inclined to a vertical line at an angle whose tangent is 0.25; (b) the crest of the weir must be perpendicular to the axis of the ditch; (c) the upstream edge of both crest and sides of the weir must be sharp, and the walls cut away therefrom to prevent the creation of a vacuum; (d) the distance of the crest of the weir from the bottom of the flume must be three times the maximum depth of water intended to pass over the weir, and the distance from the end of the crest to the sides of the flume must not be less than twice the maximum depth of water to flow over the weir.

(4) The float which actuates the recording instrument should be placed far enough away from the weir to secure an accurate measurement of depth. This is 6 ft. in the sketch.

(5) A post for checking the record of the register should be fastened to the bottom or sides of the flume, with a nail in its top exactly level with the crest of the weir. The accuracy of recorded depths should be tested each time the sheet on the register is changed.

(6) The depth of water on the weir can be determined by the following method: Having the perpendicular distance from the top of the cross beam to the top of the post referred to (5), measure the top of the cross beam to the water surface either with finely-graduated scale or hook gage. The difference between these two distances will give the depth of water required.



Transverse Section. Vertical Section A-B.

FIG. 4. DRAWINGS SHOWING THE MECHANISM OF THE HERCULES DRILL.

MEASURING FLUMES.

Fig. 2 is an isometric projection of the measuring flume proposed to be used where conditions do not permit of a weir. In constructing these flumes, the following requirements must be observed: (1) Bottom of flume (Fig. 2) should be horizontal in both directions; the sides vertical. The length must in no case be less than 12 ft. nor less than twice width of the ditch or canal, and width must be equal to width of ditch on the bottom.

*Published through the courtesy of the U. S. Department of Agriculture, Office of Experiment Stations, Dr. A. C. True, Director.

†Expert Assistant in Charge of Irrigation Investigations, Cheyenne, Wyo. The first 18 paragraphs were prepared by Mr. Elwood Mead, M. Am. Soc. C. E., Expert in Charge of Irrigation Investigations, Washington, D. C., and published in Bulletin 86, Irrigation Investigations, etc. Figs. 1, 2, 5 and 6 were also included in the same bulletin.

(2) The upstream end should have a submerged apron, extending 2 ft. below the bottom, to prevent leakage. The wings at the sides should extend into the bank beyond the surface water line of the ditch, and the angle of inclination to the axis of the ditch should not exceed 30 degrees.

(3) The channel of the ditch should have a uniform grade and cross-section for 100 ft., upstream from the flume, and should be straight for that distance, with its axis passing through the middle of the flume and parallel to it.

(4) The well for the register float should be placed three-fourths of the distance from the upstream end of the flume.

(5) The well for the register float for both weirs and flumes should be made large enough to contain both float and counterweight, in order to protect them from the action of the wind. To do this it should be 10 or 16 ins. inside measurement in cross-section, and its height above the bottom of the flume should be more than double the maximum depth of water the flume will carry.

(6) Where the water carries solid matter in suspension the bottom of the flume should be about 0.1-ft. above the grade of the ditch, so that all silt may be carried through and not permitted to settle and destroy the form of cross-section.

(7) The foundation timbers of all structures should be solidly embedded, and the earth around them and around the sides of the structure carefully and solidly rammed, in order to prevent any subsequent settlement or passage of water around either the bottom or sides.

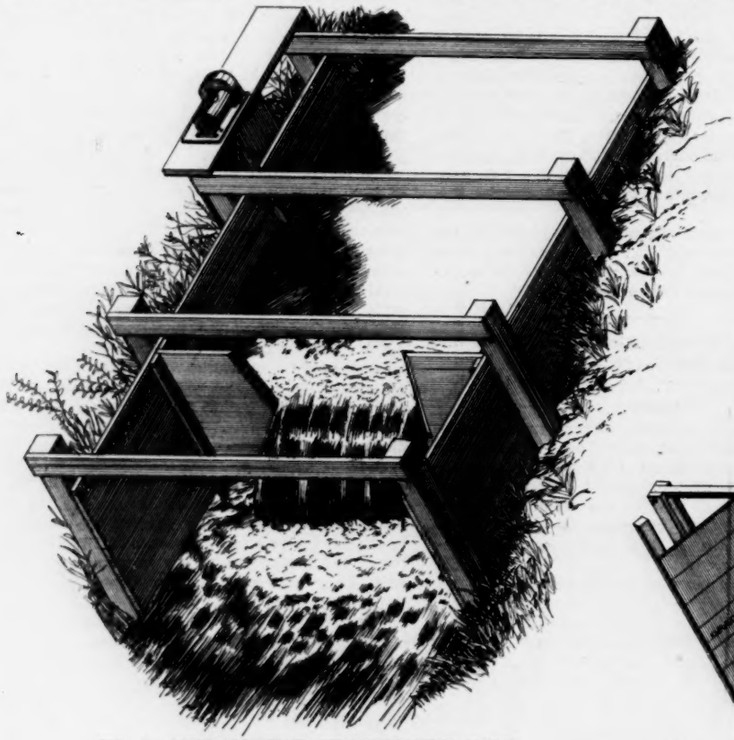


FIG. 1. ARRANGEMENT OF CIPPOLETTI WEIR.

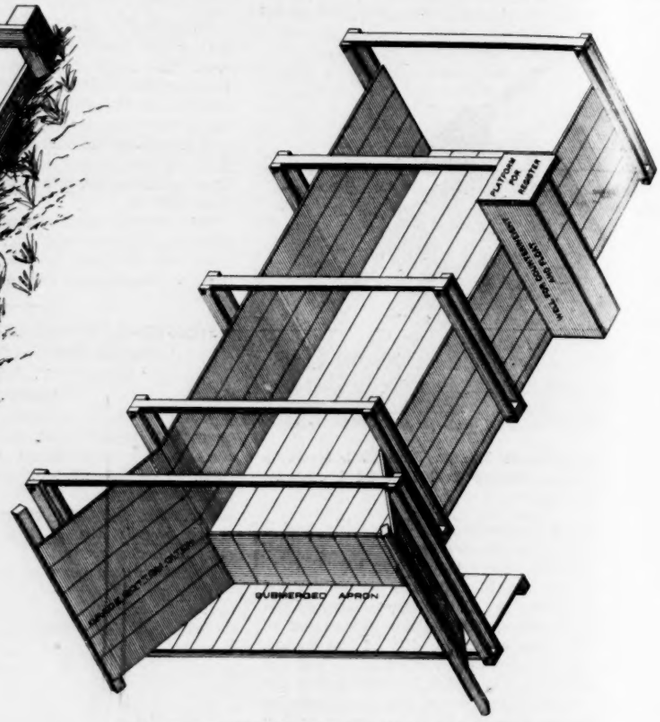


FIG. 2. MEASURING FLUME AND REGISTER.

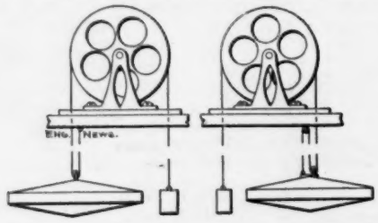


Fig. 3. Fig. 4.

Figs. 3 and 4. Arrangement of Pulleys to Magnify the Record of Water Registers.

INSTALLING REGISTER.

The following instructions should be observed in placing the register: (a) The distance from the bottom of the register to high water mark must be 6 ins. more than the total rise and fall of the water.

Record sheets provide for eight days, but clocks should be wound and paper changed once each week. The sheets are designed for this to be done on Saturday.

The accuracy of the registered depth of water flowing over a weir or in a flume should be tested before and after the change of each sheet. Any inaccuracies in either depth or time should be noted on the sheet when observed and the same corrected. Care should be observed in returning the pen to starting point that the gear and pinion do not become marred. The ball-bearings should be oiled once each month. The ink in the pen, if a pen is used, should be renewed each week. The report of land irrigated and the register sheets showing the depth of water should be mailed each week to the Cheyenne office.

If observers desire to keep a copy of the register sheets extra blank sheets will be furnished them upon which the record may be traced. The originals in all cases should be sent to the office.

(b) Before installing the water register the weir or measuring flume should be carefully constructed and a platform and well for the instrument itself should be built. The well for the float should be connected to the water in the measuring flume or above the weir by a small pipe or hole bored by a gimlet. The platform upon which the instrument rests should be horizontal, and should be far enough above the water so that the weights will have plenty of room to move without touching the surface. It may be impossible to install the instrument high enough so that the counterweight for the float does not touch it at times. If possible, however, this should be provided against. The weight which moves the pen carriage on the instruments of later design should in no case touch the water. The float and weights should be boxed in so that the wind will not affect the accuracy of the record.

(c) After this preliminary construction has been finished place the register on the foundation before the wires or cords connecting the weights and the float and counterweight are attached. With a lead pencil mark around the edge of the base so that the register can at any time be replaced in the same position. With a small pencil or sharp-pointed instrument mark on the board the places where the holes must be bored for the cord or wire. The register can then be removed from the foundation and the holes bored.

(d) The circumference of the drum on all the instruments in general use is 1 ft. The register sheets are made to fit the different instruments whether the cylinders are 8 or 12 ins. in length. After considerable experiment a paper has been found which takes the register ink well, and all stations supplied with instruments from the Office of Irrigation Investigations will be furnished with sheets printed on paper of this quality. The ink is also furnished by the office. It contains glycerine in its composition, which largely prevents evaporation. The presence of this fluid adds to the danger of the ink spreading on the paper before it dries. For this reason it is very desirable that the pen make a fine line.

(e) After the instrument has been carefully installed and the clock has been regulated it will not be necessary to remove the cover of the clock-case unless it is evident that the pen is not moving over the time spaces at the proper rate. Sliding-doors have been provided in the back of the clock-case so that it can be wound and another door has been placed opposite the balance wheel so that the clock can be started or stopped at will. Instruments of late pattern have a glass window in the case so that the record can be examined at any time without disturbing the register.

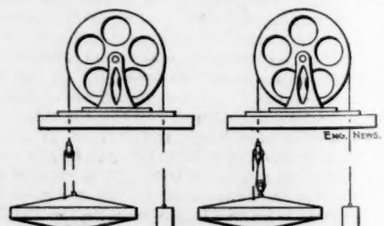


Fig. 3a. Fig. 4a.

Figs. 3a and 4a. Arrangement of Pulleys to Reduce Record of Water Registers.

(f) It will be found that the register sheets when applied to the drum do not fit easily unless they are kept in a damp place. The sheets for two or three weeks or a month ahead might be kept under a dampened blotter or cloth until

needed. The narrow margin should be trimmed to the printed lines. In case the pen does not travel over the lap in the register sheet as easily as it should the paper at the lap can be beveled with a sharp knife or rubbed with a dull instrument while the paste or mucilage is drying. The pen is filled by dipping a match, or other small piece of wood, into the ink bottle and allowing a drop to enter its cylinder. It seldom occurs that the pen will mark until the ink has been brought through the same by opening the nibs with a small knife blade or similar instrument. The pen is quite a delicate instrument, and great care should be taken not to bend it out of shape. Should this happen the pen will have to be removed from the arm and the nibs bent into position. Should the pen make a broad mark it is generally an indication that the nibs are too far apart. To remedy this, remove the pen from the arm, insert a match in the cylinder of the pen and with the thumb and finger, or small pair of plyers, bend the nibs toward each other. Remove the match and examine the points with a magnifying glass. It may be necessary to grind the points of the pen after they have been bent in this way in order that they may be made the same length and be smooth. Only the finest kind of oil stone or hone should be used for this purpose. The pressure of the pen on the paper should be no more than that produced by its own weight. This should be regulated by bending the arm of the pen.

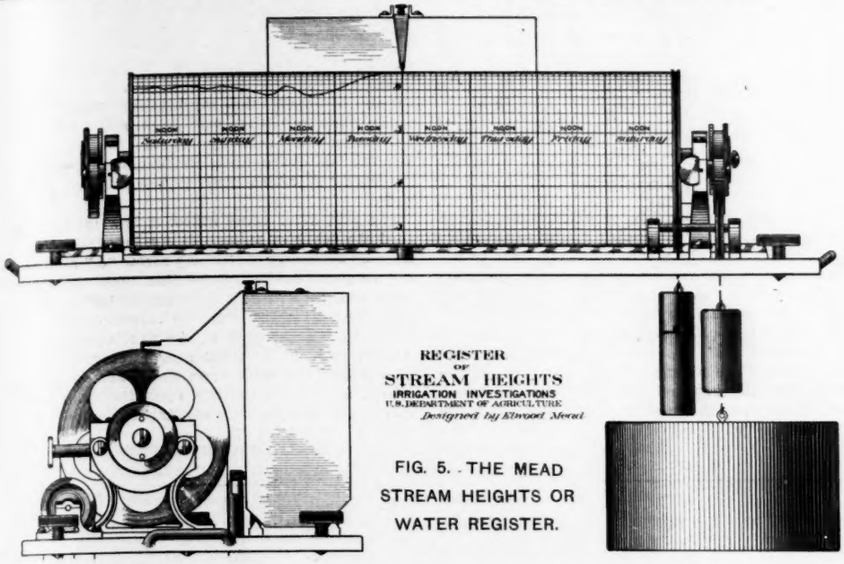


FIG. 5. THE MEAD STREAM HEIGHTS OR WATER REGISTER.

(g) To begin a week's record place the pen on the register sheet at the time of day the record commences. The depth shown by the position of the pen on the register sheet should agree with the depth of water in the flume or over the crest of the weir. This latter adjustment can be made by slipping the cord or wire running over the drum in the direction necessary to correct the error.

(h) The register sheets are fastened to the drum by lapping one end over the other and applying a small quantity of library or similar paste. This paste should be applied under the printed edge, which should be lapped over the wide margin at the other end of the sheet. To remove the sheet at the end of a week's record care should be taken not to scratch or injure the drum. This can easily be avoided by taking a sharp knife and cutting the paste. The sheet is then removed without injury and the drum is at all times protected by a layer of the paper. The register should be visited each day during the first week it is installed. If it continues to run uniformly and give good results, it need not be watched so closely during the remainder of the season.

(i) The floats for a large number of water registers are made of copper. They are circular and are from 6 to 8 ins. in diameter, and 1 to 3 ins. high. The top and bottom of the float are conical. To make the float steady in the water it is generally necessary to weight it by pouring in either fine shot or melted lead. The latter method is preferable as the ballast does not easily shift. The counterweights are of lead, and they vary in size according to the use to which they are put.

(j) It may be necessary to reduce or magnify the record made by pen or pencil on the register sheet. Where considerable depth in fluctuation of the flowing water occurs in a short time it is necessary to reduce the record. In evaporation records, and when testing the accuracy of the water register, it is often desirable that the record be magnified. Both of these changes in the record can be brought about by a system of pulleys connected with the float.

If it is desired to increase the record twice, secure a weight a little heavier than the one accompanying the instrument. Fasten the end of the cord and suspend the float on a pulley, as shown in Fig. 3. When the float rises or falls the counterweight takes up the slack in the cord or wire and the cylinder revolves twice as fast as the water fluctuates in depth.

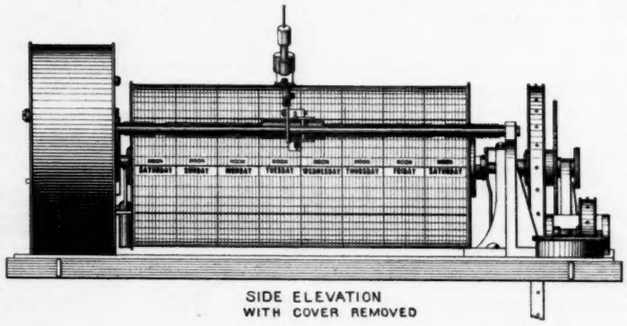
If it is desired to increase the record three times, a pulley is also fastened under the base of the instrument, as shown in Fig. 4. The cord running from the cylinder passes through the pulley in the float, thence through the pulley under the base and is then brought down and tied to the float. A counterweight for this purpose should be slightly heavier than the one ordinarily used.

If it is desired to reduce the record, a little different design of float must be used, as the cord must pass through it and be tied securely to the bottom of the well, which contains the water upon which the float rests. This hole must be made so that no water can enter the float. Fig. 3a shows how the record can be reduced one-half by the arrangement. The pulley is tied to the cord or wire, which passes over the cylinder.

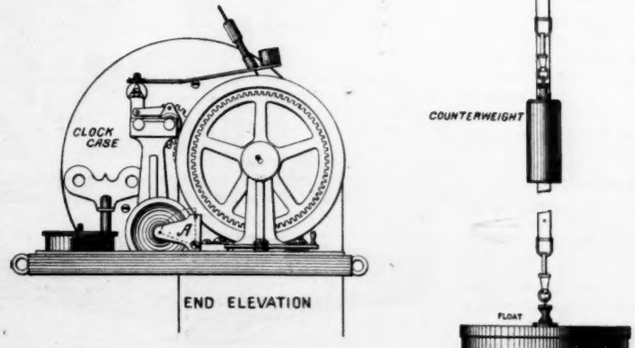
Another cord or wire is attached to the float and passes through this pulley, thence through the hole in the float and is tied to the bottom of te well before referred to. Only one-half of the rise and fall of the water in the well is transmitted to the cylinder by this device.

Fig. 4a shows how the record can be reduced one-third. This device is the same as that shown in Fig. 3a, except that there is a pulley on the float, and the cord, passing through the two pulleys, is fastened to the frame of the copper one. The counterweight should be slightly heavier than the one ordinarily used.

It is not desirable to make the system of pulleys any more complicated than is necessary to magnify the record three times or reduce the same one-third.



SIDE ELEVATION
WITH COVER REMOVED



A - POSITION OF REDUCING GEAR WHEN NOT IN USE.

FIG. 6. THE FRIEZ STREAM HEIGHTS OR WATER REGISTER.

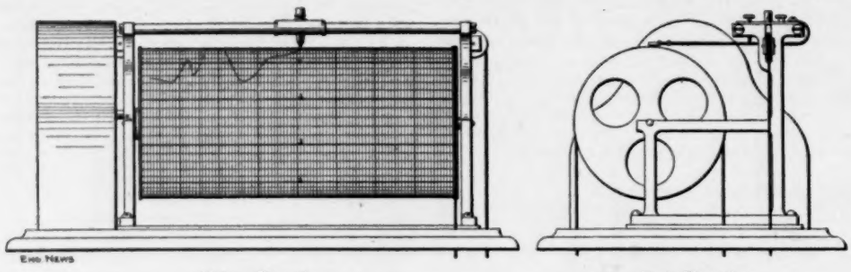
GURLEY WATER REGISTER.

To install the Gurley water register great care should be taken in protecting the clockwork. The clockwork is not provided with a case, and it only requires a small amount of sand to stop or retard the motion of the balance wheel. As the clockwork propels itself the track should be kept clean, as should the small wheels which run on the same. Care should also be taken to keep the rack and pinion in good condition. A large number of these instruments are supplied with pencils. These should be kept sharp, should be no harder than a No. 3, and should be turned two or three times a week so that no one part will become worn and produce a broad unsatisfactory line.

The register sheets for these instruments are 1 ft. square. The day spaces are 1½ ins. wide, making eight complete spaces beginning and ending with Saturday.

These instruments are furnished with ball-bearings. In shipping them the weight of the cylinder is thrown off the balls by turning the milled stop to the right or left, when a spring draws it under the bearings. Before installing, this stop should be pulled out and turned so as to catch securely.

In the improved Gurley register the clockwork in all respects conforms to the clockwork of the new Standard register, and the instructions covering this feature of the latter should be followed in installing the Gurley machine.



Side Elevation. End Elevation.

FIG. 7. THE LEITZ STREAM HEIGHTS OR WATER REGISTER.

THE FRIEZ REGISTER.

When the Friez register is shipped, the float is attached at one end of the case. A counterweight is secured to the base of the instrument, and the copper band which runs between the counterweight and float is contained in a small case directly under the counterweight. To install the instrument the copper band is placed over the large wheel at the end of the drum if it is desired to secure a record on a natural scale. If the fluctuation of the depth of water is considerable it may be desirable to reduce the record one-fifth. In this case, the band is put over the small wheel which is geared to the large one. Great care should be exercised in handling this copper band. It is liable to stretch or kink, and if it should be injured in either way, it will be quite difficult to remedy the trouble. The carriage which holds the pen or pencil is moved along the screw thread at will by clamping together the two levers which project beyond the screw away from the drum. The pen or pencil can be set to the proper time by simply moving this carriage. If it is more convenient in attaching the register sheet to the drum the latter may be removed from the bearings by pulling out the milled screw at one end.

The clockwork is protected from the weather and dust by a metal case. It can be wound without removing the cover from the case.

THE LEITZ REGISTER.

The operation of the Leitz register is somewhat similar to those already described. The pen carriage is moved by a counterweight which is released by the clock. The carriage sliding on two parallel rods can be adjusted at any place along the cord connecting the clock and weight by loosening one of the set screws. This seldom has to be done if the register sheet is taken off at the same time each week.

The carriage is then brought back by turning the ratchet attached to the drum on the main spring shaft of the clock. A small tool is furnished with the register for this purpose. An improvement for bringing the pen back at the end of the week has lately been devised. A counterweight is hung below the clock so that as the drum unwinds the cord from the counterweight is wrapped around the same. At the end of the week, to bring the carriage back to the point of beginning, all that is necessary is to pull downwards on this counterweight and the ratchet wheel moves until the carriage has been brought back to the proper place.

THE STANDARD REGISTER.

The accompanying figure (8) shows the latest design for water registers manufactured by the Modern Machine Works, of Denver, Colo. The base is of cast iron, the standards, rods and cylinder for the register sheet of cast brass. The clockwork, which will run eight days, and which moves the pen 1 in. each day, is securely fastened to the iron base of the machine beneath the rods upon which the pen carriage slides. This arrangement of the clock enables a base to be constructed which has considerably less length than would otherwise be required.

The wire which transmits motion to the pen may be of fine brass or tinned-iron of about 33-gage, plain iron wire being more liable to rust. If desirable, the ends of the register cylinder may be reversed so that the days of the week will run either way as desired. When a reversal is made, however, the pen should be turned around on the arm so that it will cross the lap in the paper without difficulty, and the power wire "g" must be rewound and in an opposite direction on the narrow brass drum "F." It is probable that the majority of these machines will admit of running the pen from left to right only, since no opening in the standard "H" was provided in the drawings sent to allow the passage of the wire through the same from the grooved pulley "e," to the lower side of the narrow drum "F." Reference is made to the machine as it appears in the drawing with the clockwork between the observer and the large register cylinder.

To wind the wire "g" upon the drum "F," fasten one end to the drum by inserting through small hole in the rim and then back and forth through the drum laterally a few times, taking care to leave no knots, loops or projections that may cause friction. Thread the other end through the standard at the base of the pulley "e," draw over the pulley, continue through the hole in the base of the pen carriage, and over the pulley "e," at the right end of the rods, allowing same to pass through the hole in the base where the counterweight is attached. The wire should be more than 8 ins. long below the base to allow of winding at least 8 ins. upon the drum "F." Having attached the weight, move the pen carriage to the right end of the rods, and turn down the set screw "d" until the carriage no longer slides along the wire. Now, with finger and thumb turn the pinion "E" over and toward the clockwork, winding the wire upon the drum until the pen carriage "f" slides over to the left end of the rods.

The pen, after being inked, is now ready to record the depth of water. It can be adjusted as to time by releasing the thumb screw "d," and moving to point desired, depending upon the day of week and time of day the machine begins its record. The set screw must be turned down snugly upon the wire as soon as the pen is properly set. At the end of the week repeat the performance of winding the wire upon the drum. A ratchet wheel, similar to the one upon the front of the clockwork, enables this winding to be done.

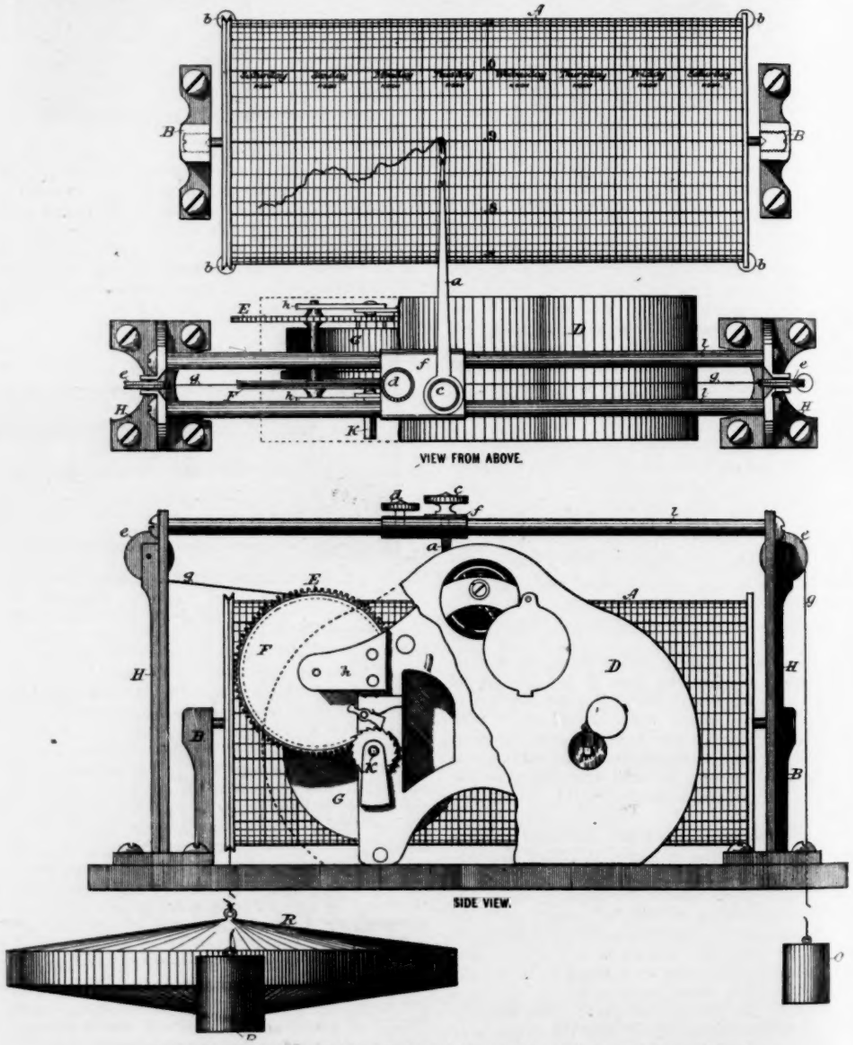


FIG. 8. THE STANDARD STREAM HEIGHTS OR WATER REGISTER.

A NEW USE FOR CEMENT MINES has been discovered by the Union Akron Cement Co., of Akron, N. Y. This company has an old abandoned cement mine which it has leased for the purpose of cultivating mushrooms. The mine is some distance below the surface of the ground and has an even temperature of 50° throughout the year. It is specially adapted to mushroom culture, and the product is largely shipped to the New York market.

FIXING RESPONSIBILITY FOR THE FALL OF A CONCRETE-IRON FOOTBRIDGE AT THE PARIS EXPOSITION.

The fall of a concrete-iron footbridge, at the Paris Exposition, on April 29, 1900, caused the death of eight persons and the injury of eight others. The decision of the court on this case was recently published in "La Loi," of Paris, and from this decision we gather the following particulars:

A company organized to build and exhibit an enormous globe, just outside the Exposition grounds, contracted for the erection of a footbridge over the Avenue Suffren; the bridge to be built of concrete and iron on the Matrai system. The bridge was completed and the centering removed; but before it was opened to traffic the structure fell, as above stated, with no load but its own weight. The engineers and constructors of the bridge were brought to trial on the charge of criminal negligence.

The expert engineers testifying during the trial ascribed the failure of the bridge to two principal causes: (1) The weakness of the columns supporting the girders; these columns were only 30 cm., or 11.8 ins. square, excepting four, which were 14, 15.2 and 16 ins. square. Several of these columns were often struck by carriages passing along the Avenue Suffren. (2) The method of supporting the main girders spanning the Avenue Suffren was dangerous in the absence of any means of taking up the oblique stresses.

The judge decided as to M. Galeron, the managing director of the Celestial Globe Co., that he was practically his own contractor, paying the workmen and buying the material. Galeron claimed that the erection of the bridge was superintended by the engineer, M. Tedesco; and he stated that he never had a complete plan and depended solely upon Tedesco. The judge held, however, that Galeron was gravely negligent in assuming to erect so important a work without satisfying himself beyond doubt that the public was not endangered. It also appeared that Galeron ordered a modification of the plans of the structure to make them conform to the location of some trees on the avenue, which the city authorities would not allow him to remove; and as a result two offsets were made in the structure, so that the girders and columns were not in exact line. Galeron was also negligent, the judge ruled, in allowing people to pass under this bridge after removal of the falsework before it had been submitted to tests as to its sufficiency.

As to M. Tedesco, the judge found that he was the Engineer-in-Chief of the Celestial Globe Co.; that it was upon his advice that M. Galeron asked the Societe Anonyme des Constructions en Fer-beton to make the necessary calculations for the building of this bridge in armed-cement; that it was under his direction that the work was executed; and that he was present every day at the bridge to give instructions to the workmen. Under these conditions it was impossible that he should not have noticed the two offsets that were so condemned by the experts, the light dimensions of the columns, and the dangerous method of supporting the girders without provision against oblique stresses. Tedesco declared that Matrai, the designer of the armed-cement structure, knew of these two offsets, but declared to him that they had no effect upon the solidity of the work. Tedesco, contrary to the opinion of the experts, declared that the system carried out was correct, and that provision against oblique stresses were not necessary. Tedesco further said that he never had had a plan, nor the calculation for the stresses; and that he had only figured upon a sheet of quantities for the iron. He contended that his sole duty was to see that the instructions of the designer, M. Matrai, were strictly carried out, including the removal of the centers three days before the accident. The judge decided, however, that as Tedesco was the Chief Editor of a journal called "Le Ciment," and therefore had a special and extended knowledge of work of this nature, and yet had not noticed the defects of this structure, he was guilty of the most culpable negligence.

M. Matrai, the designer of the bridge, was the technical director of the Societe Anonyme des Constructions en Fer-beton. In this capacity he made the calculations for building this structure. He declares that he was not required to watch the actual construction, and was only responsible for technical errors made in the calculations; and he affirms that he did not commit any of the latter. He said that he never fixed upon the final plan, on which the bridge was built, but only submitted proposed plans, and these were not carried out. These proposed plans called for columns 16 ins. square, whereas all but four were only 11.8 ins. square. Nor did he contemplate any offsets, such as were made in building the structure.

As against this testimony, M. Tedesco insisted that the official plans furnished by the Societe gave all the necessary dimensions for the work, indicating columns 11.8 ins. square. He also said that he informed M. Matrai of the two offsets made to pass a group of trees, and that by Matrai's consent the original plan was modified to permit them. Galeron confirmed this assertion. The day before the accident, however, it appeared that M. Matrai wrote his employee, Heim, that he found the columns under the footway too weak, because the iron in them did not conform exactly to the form designed, and the cables were not properly stretched; that unless these columns were reinforced, he would not be responsible for their safety.

The judge held, however, that it was impossible to determine exactly when or by whose orders the dimensions of the columns were changed; and it could only be assumed that this order resulted from some understanding between MM. Matrai and Tedesco. In any event, if Tedesco ordered the change without consulting Matrai, the latter should have noticed the change on his visits to the work. Further, the expert M. Debrie testified that while 16 ins. square column was sufficient for a bridge with the girders and posts in a line, this dimension was not sufficient for a skew bridge; and in so designing it Matrai committed "a grave error, an enormous professional fault."

In summing up the court decided that each of the three was equally guilty, and condemned Galeron, Tedesco and Matrai each to two months' imprisonment and a fine of 600 francs, but applied to each the law of "sursis," or suspension of the bodily penalty. This is an exceedingly light penalty for the death of eight people, as the result of faulty plan and construction.

Mr. Von Emperger, of Vienna, to whom we are indebted for the decision in question, in commenting on this accident, says that the experience proves what is already known—that while a beam encased at both ends is stronger than one not so encased; this gain is entirely due to the character and strength of the walls or piers supporting the beam. It these cannot endure the stresses which the beam throws upon them, then the latter can carry no more load than a beam not encased.

THE DANGER OF ELECTRIC LIGHT AND TROLLEY WIRES TO FIREMEN WHEN FIGHTING FIRES.*

By Morris W. Mead.†

In running overhead high potential wires in the business portion of most cities, there is too much carelessness in the arrangement of the circuits. I believe all electric-light circuits should be run in parallel, and at regular intervals lead off to switches, and that such locations should be numbered and blue prints of every switch and of the location of every circuit should be prepared and kept on file at the headquarters of the fire department. These should all be carefully studied and gone over either with an expert of the local company, or with a competent city electrician. The firemen should be trained and instructed in handling the switches, as well as in general electrical principles, so as to understand the easiest and safest manner of handling them in case of emergency. Every circuit should be labeled at regular intervals with the voltage it carries, and all controlling devices should be made to correspond. Trolley wires can be arranged on the same principle, so as to be able to cut them out at every 1,000 or 2,000 ft. in crowded cities, and these places can be carefully marked and records placed on file at department headquarters. In the larger cities, one or two electricians should be attached to the fire department and go to all fires, to assist and to instruct the members of the department in self-protection from high potential currents.

One of the best remedies for danger from overhead wires is for cities to compel all wires to be placed underground in the business portions of the city and on all main avenues. Electric light companies in all cities can afford to do this, but all cities are not so situated as to make successful the underground trolley system. While New York city and Washington might successfully do this, yet I would doubt its feasibility in Pittsburg, or in any city where there are so many hills or where rivers sometimes flood the lower streets. In all cities, however, trolley feed wires can be placed under ground and feed outlets arranged at stated intervals, thus doing away with much of the obstruction and some of the danger.

The next step, towards doing away with electrical dangers should be a complete city control over these matters; ordinances should be passed placing supervision of overhead wires in the hands of a competent city electrician, or, as above suggested, compel underground construction.

Another safety arrangement which naturally suggests itself in the protection of firemen, in fighting fires, from electricity, is that all electric light and power companies, railroads included, should have thoroughly equipped wagons, located at reasonable intervals along their lines, with competent men in charge, to respond in every case of fire. This, I should think, would be a good thing for the companies themselves from the standpoint of economy, to say nothing about the protection it would afford to the firemen. Gongs connected with the fire department lines should be in all such headquarters, and if necessary there should be two crews attached, to relieve each other, or else to sleep there regularly as firemen do and answer day and night. Another convenient preventative is to have on hand rubber boots and rubber gloves, to be furnished to the firemen with insulated pliers, with which they can cut wires in case of necessity.

*Extract from a paper read at the Indianapolis meeting of the International Association of Fire Chiefs.

†Superintendent Bureau of Electricity, Pittsburg, Pa.

A MINING EXPOSITION is to be held in the Grand Central Palace, New York city, beginning Dec. 2 and lasting 15 days. There will be displays of manufacturing and commercial tools, machinery and supplies; ores, oils and other minerals; concentrates, metals and non-metallic products; maps and illustrations of mineral resources by railway companies; scientific displays of minerals by states, mining bureaus, schools and individual collectors; pictorial exhibits of ores and products by corporations engaged in mineral industries, including mineral springs and "water mining," with drilled, bored and driven wells. Exhibits representing the petroleum industry will be given due prominence. A historical and entertaining feature is to be the reproduction of a frontier mining camp, with genuine hand-made tools, utensils, apparatus, structures and furniture used by the miners.

THE RAILWAYS OF INDIA aggregated 24,707 miles in length on Dec. 31, 1900, the new construction during 1900 amounting to 1,237 miles. There were also 78.44 miles of steam tramways, outside of municipal limits. The mileage authorized but not yet constructed amounted to 2,228 miles. The traffic comprised 174,824,483 passengers, with an average haul of 40.09 miles; and 43,615,289 tons of freight, with an average haul of 153.57 miles. The first-class passengers numbered only 655,000, while those of the fourth class numbered 164,400,000. The train mileage was 34,328,845 passenger train miles, and 49,729,419 freight train miles. The operating expenses represented 47.79% of the gross earnings, which is about the average annual percentage. The railways have been hampered by lack of rolling stock, but during the year the rolling stock equipment was increased by 155 locomotives, 539 passenger cars and 3,392 freight cars, for lines of 5 ft. 6 ins. and 3 ft. 3⅜ ins. gage. Orders were also placed for 331 engines, 878 passenger cars and 7,352 freight cars. There are now 1,569 engines and 8,670 cars fitted with automatic brakes, and 5,486 cars fitted with the Pintsch lighting system, leaving 2,056 engines and 70,325 cars yet to be fitted with brakes, and 4,259 cars to be fitted with lighting equipment on the railways using gas. The use of automatic brakes is confined to railways with fast passenger trains or running over lines having steep grades. The railway employees number 350,177; of these only 5,367 are Europeans, 7,295 are Eurasians (or half-breeds), and 337,515 are natives. Practically all of the first two classes are enrolled in the volunteer military service. On the larger railways, schools are maintained at all centers where the number of children is large enough to warrant the employment of teachers, and during the year the numbers attending school included 6,242 children and 3,828 apprentices and workmen. The important engineering works completed during the year included some long bridges or viaducts, as follows: The Sone (Dehri) bridge on the Moghal Sarai-Gya extension of the East Indian Ry., 93 spans of 100-ft. girders; the Mahanaddi bridge of the Bengal Nagpur Ry., 64 spans of 100 ft.; the Kuakhai and Kathjori bridges of the same railway, with 20 and 18 spans of 150 ft., and the Roopnarain bridge of the same line, with 7 spans of 300 ft. and 4 of 100 ft.; the Havelock bridge carrying the East Coast Ry. over the Godaveri River, 56 spans of 150 ft. and 1 of 40 ft.; the Indus bridge of the Northwestern State Ry. at Kotri, with 5 spans of 350 ft. and 1 of 100 ft.; the Gokteik bridge of the Burma Rys. (Eng. News, Feb. 28, 1901).

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

Evidence accumulates that the long-talked-of project for a bridge across the Hudson at New York city is receiving serious consideration by the railways terminating in Jersey City. The Erie R. R., two or three years ago, elevated its tracks for a considerable distance in Jersey City, and eliminated several street crossings at grade. Work was begun at the same time on a new line, known as the Penhorn Creek R. R., which was planned to cross the Bergen hill by an open cut above the present tunnel, and thus avoid the use of the tunnel by passenger trains.* The foundations were built for a viaduct approach to this road, leaving the main line in Jersey City. Work on this road has been at a standstill for more than a year, however, and in the annual report of the Erie recently issued, it is stated that the stoppage of work is due to the possibility of bridge or tunnel construction across the Hudson in the near future, and the changes in terminals which such a construction would render necessary.

The "Journal of Commerce" states that the financial arrangements under which it is planned to have the bonds for the bridge construction guaranteed by the various railways terminating in Jersey City are in the hands of Mr. Samuel Rea, M. Am. Soc. C. E., Fourth Vice-President of the Pennsylvania R. R. That corporation is likely to make largest use of the bridge and to furnish the largest share of the necessary financial backing.

Traffic on the Manchester Ship Canal for the first six months of 1901 was 84,000 tons less than in the first half of 1900. About half of this falling off is claimed to be due to the reduced shipments of coal, on account of temporary conditions in the coal trade. It is nevertheless true that Liverpool and other competing English ports are improving their dock facilities, and will endeavor to retain as much as possible of the trade which Manchester seeks to secure. Until the present year, traffic on the canal has shown a steady growth every year since its opening, and with the rapid growth of industries in the Manchester district, further growth is pretty certain to take place, though it will probably not be continuous or at the same rate as in the past.

*Eng. News, Aug. 18, 1898.

Mr. Edward Atkinson and the Mutual Boiler Insurance Co., of Boston, of which he is the President, have been investigating the subject of Smoke Prevention, and the results are embodied in a circular (No. 10a) recently issued by that company. A table attached to this circular gives the replies received from 100 manufacturing concerns to whom inquiries were sent relative to their experience with smoke and smoke prevention. Incidentally, the table is a somewhat interesting revelation of human nature. Mr. Atkinson, with characteristic bluntness, set down as one of the questions in his circular of inquiry: "Do your chimneys smoke badly?" Naturally, the managers of factory plants are not likely to admit that their chimneys "smoke badly," no matter how many cubic yards of soot are rolling out of their tops. It is not strange, therefore, that only two men out of the whole hundred answered this question with a plain unqualified "yes," while 61, a good share of whom were burning soft coal without anything in the way of smoke-preventing devices, gave a flat-footed "No." The remaining 37 answers "hedge" more or less. Many explain that smoke occurs when the boilers are fired. One honest fellow admits that they smoke "pretty badly," and another cautiously replies "there is smoke."

Next Mr. Atkinson shrewdly inquires whether there are any complaints in the neighborhood of soot from the chimneys or the dropping of fine ashes. The man whose chimneys smoke "pretty badly" admits that there is complaint, and so do three others. Two others have heard complaints regarding other people's chimneys, but not their own, of course, and one conscientious manager, after pleading guilty to making the "usual amount" of smoke from his chimneys, remarks that "there is no complaint, but there ought to be!"

Forty out of the hundred have used or are using some sort of smoke-preventing device, some eight or ten different kinds being enumerated. It is worthy of note that with unimportant exceptions all these are reported to be working with a good degree of satisfaction, and in the majority of cases they are believed to be saving money for those who use them. The saving, however, appears to be quite as much in economy of boiler room labor as in fuel consumption.

There has long existed a prejudice among engineers against iron or steel containing small percentages of copper. Many specifications for steel in the past, and very likely some still in use, fixed maximum limits for copper as for phosphorus and sulphur. How this prejudice against copper in steel originated we do not know; but that it is wholly baseless seems to be clearly proved by the results obtained by the most recent experimenters. In the "Journal of the Iron and Steel Institute," just issued, we find a paper by Messrs. J. E. Stead and John Evans, in which is set forth the results obtained by numerous investigators, together with independent tests made by themselves, all tending to prove that copper in any amount below 1.3 per cent. does not injure the quality of steel.

Mr. Stead, it will be remembered, is among the most prominent of British metallurgists, and received this year the Bessemer gold medal. Among the authorities which he quotes in support of his position are Mr. H. H. Campbell, M. Am. Soc. C. E., of the Pennsylvania Steel Co.; Prof. J. O. Arnold and Mr. Albert Ladd Colby, M. Am. Soc. M. E., of South Bethlehem, Pa. The conclusions reached by Messrs. Stead and Evans from the work of the other experimenters named, together with their own careful tests, we quote as follows:

1. Between 0.5 and 1.3% copper has no deleterious effect on either the hot or cold property of steel.

2. A very large amount (2%) makes the steel more liable to be overheated.

3. In small quantities it slightly raises the tenacity and the elastic limit, but, unlike phosphorus, does not sensibly make the steel liable to fracture under sudden shock. Like carbon, it reduces the power of the steel to extend under stress, but this is not pronounced when the quantity is small. The effect is more marked when large quantities are present.

4. If the evidence of the tests of open-hearth steel made by the authors can be confirmed, copper, instead of producing redshortness, has the contrary effect of changing redshort steel into steel which will roll without cracking.

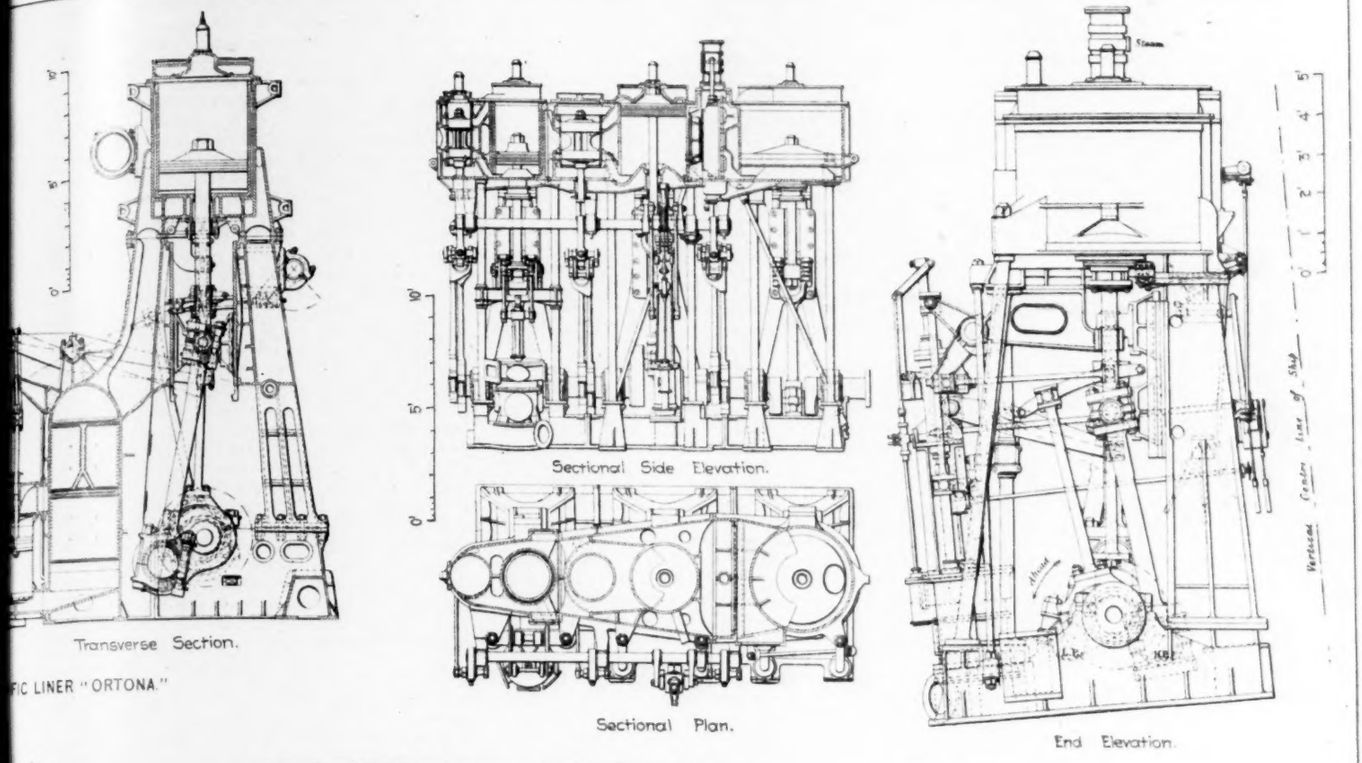
RECENT PRACTICE IN ELECTRIC RAILWAY CONSTRUCTION AND OPERATION.

In the earlier days of street railways (and up to within quite recent years), or as long as animal power was practically the only system of traction employed, and the speeds were consequently low and loads light, engineers were comparatively rarely employed in the construction of the lines, except perhaps in the larger cities. The contractor and a construction foreman were able to meet practically all technical requirements. With the introduction of mechanical traction, however, conditions have been entirely changed. The great development of street railways due to the general adoption of electric traction, not only for suburban service, but also for long-distance and high-speed interurban and rural service, has been attended by very considerable improvements in construction, and has opened a new field for engineers in the construction and maintenance of these lines. Country electric lines built to develop traffic in districts having no other means of communication, may be constructed at very low cost, ranging from $10,000 to $16,000 per mile (including power station and plant), as shown by an article on "Economic Railways for Country Districts," in our issue of Feb. 1, 1900. On the other hand, a double-track electric interurban line built on its own right of way, having masonry and steel structures, and designed for high-speed service, costs $31,000 per mile.

For electric lines outside of city and suburban streets, the character of the construction is usually very similar to that of an ordinary railway, especially where the track is laid on the waste space of a road reservation, or upon its own right of way.

For street lines of a second-class character, the street is often excavated only to the level of the bottom of the ties, which are simply laid upon and tamped with the natural earth, which is also filled in level with the tops of the ties. The rails are then laid and the paving placed between them. This is a very poor system for street construction, as under traffic the track soon becomes rough and uneven. The paving also gradually settles between the ties, forming a very irregular surface. The excavation should be carried below the level of the bottom of the ties, soft material being removed and replaced with gravel or cinders. The subgrade should then be rolled, and covered with a bed of slag, broken stone or gravel, well rolled to a finished depth of 8 to 12 ins. below the ties. The same material (or concrete) should be filled in between the ties to form the foundation for the paving.

In busy city streets where the construction is suitable to the conditions (which is by no means always the case), the track construction is usually of a special character. Greater permanence of surface is required than for ordinary steam railways, as the track must maintain its conformity to the surface of the street, and there is no opportunity for the continual tamping, surfacing and tightening of bolts and spikes which is done on railway track. For this reason a substantial foundation is required. A concrete foundation for the track is most desirable, either in the form of a concrete stringer under each rail, or a concrete bed for the entire track. The rails may be laid directly upon the concrete, or (in the latter case) upon wooden ties embedded in the concrete. Both of these methods are used, but there appears to be a tendency to eliminate all wood in first-class construction of this kind, the rails being connected at intervals by tie-rods or tie-bars through the webs, or by light steel ties embedded in the concrete and serving to maintain the gage.



FIGS. 17 TO 18.
ENGINES FOR TWIN SCREW CHANNEL STEAMER
"DUKE OF LANCASTER" BUILT IN 1894.

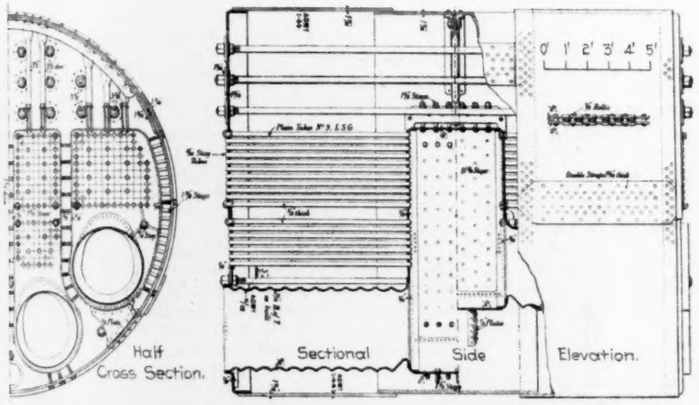
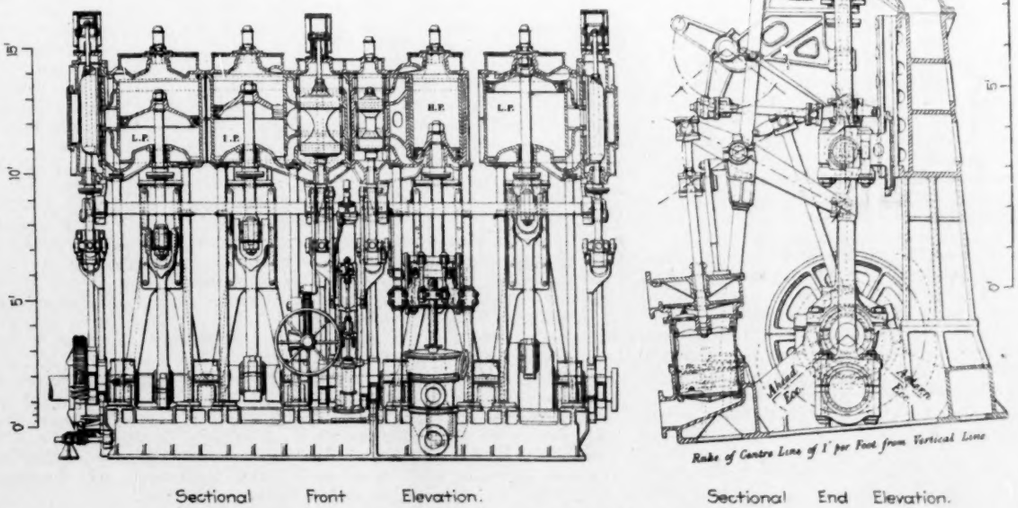


FIG 2. CYLINDRICAL BOILER FOR TWIN SCREW STEAMER "ORTONA."



FIGS 19 TO 20. ENGINES OF MODERN TWIN SCREW CHANNEL STEAMER "DUKE OF CORNWALL."

IC LINER "ORTONA."

N OF T CAL MARINE ENGINES.

CHAS. HART, LITH., 39 VESEY ST., N. Y.

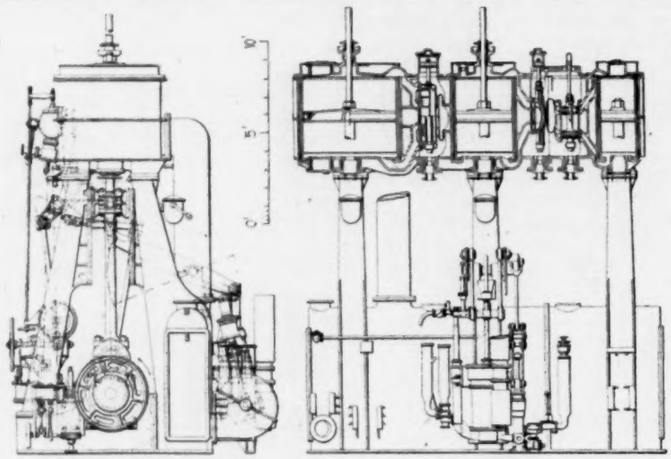
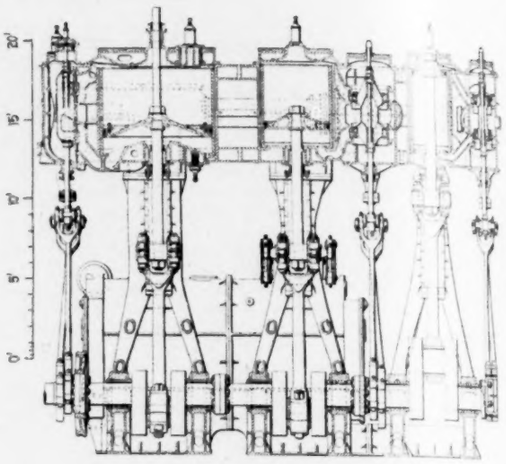
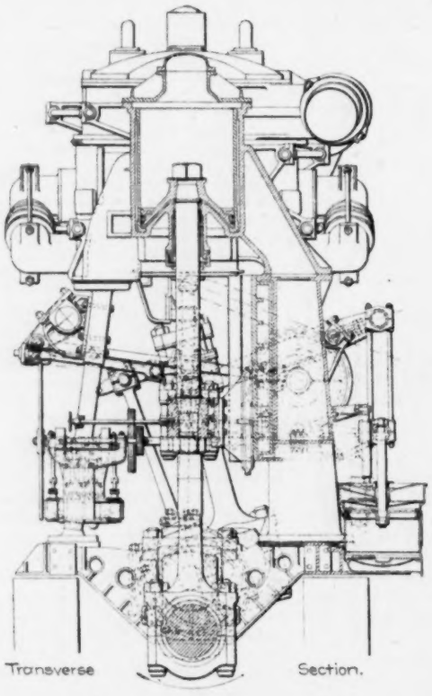
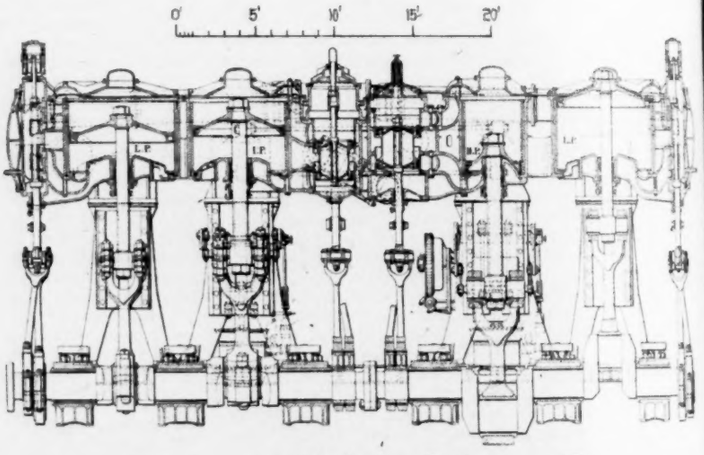


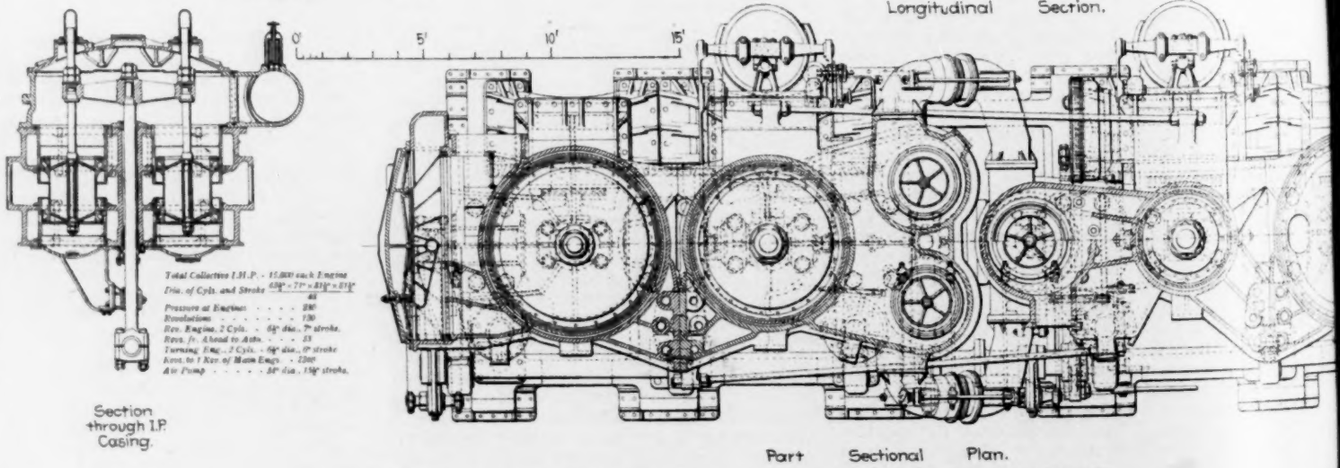
FIG. 21. ENGINE OF MODERN FIRST-CLASS CARGO STEAMERS "BORNU" AND "SOKOTO."



FIGS. 22 TO 23. ENGINE OF TWIN SCREW [illegible]FIC LINER






0'
5'
10'
15'
Total Collective I.H.P. - 15,000 each Engine
Dia. of Cyls. and Stroke
Pressure at Engines
Revolutions
Rev. Engine, 2 Cyls. - 64" dia., 7" stroke.
Revs. fr. Ahead to Astn.
Turning Eng., 2 Cyls. - 16" dia., 9" stroke
Revs. to 1 Rev. of Main Engs.
Air Pump - 38" dia., 15" stroke.
Section through I.P. Casing.
Part Sectional Plan.

FIGS. 24 TO 27. ENGINE OF ARMORED CRUISER "KING ALFRED" OF THE BRITISH NAVY.

A COMPARISON OF T[illegible]CAL

It has been contended that tracks having rails laid directly upon the concrete would be very rough riding and cause increased wear of wheels bearings and cars, but actual experience does not sustain this objection, and there seems to be no reason why a good track operated by good rolling stock should give any trouble of this kind. In fact, some of the smoothest riding track is built in this manner, and on two parts of a line where the concrete base and the wooden cross-tie system are both in use, no difference in the wear of rails or equipment has been found after careful investigations. Where a well-built track proves to be hard riding, attention may be directed to the car springs, as these have an important influence upon this matter as well as upon the wear of the rails.

In paved streets, the same paving material should be used across the entire width of the street, so as to distribute the traffic, and it should be maintained in uniform condition. Many railway companies, however, lay an inferior paving between the rails and tracks, and are very negligent as to its maintenance. In view of these conditions it has been reasonably suggested that the entire construction and maintenance of the streets, including the street railway tracks, should be in the hands of the city authorities, especially since the universal adoption of mechanical traction has eliminated the wear formerly due to the car horses. In this connection it is interesting to note that in Cincinnati, the City Engineer has authority to prescribe the style of track construction, as described in an article entitled "Municipal Notes at Cincinnati," in our issue of July 11, 1901.

Where rails with heads of the step or side-bearing type are used, the paving between the rails is sometimes laid level with the lower part of the rail head, while the outer part of the paving is laid level with the running head of the rail. This is bad practice, as it makes an irregular surface and interferes with proper cleaning and drainage of the surface. The paving should be uniform in contour across the width of the street, broken only by the grooves of the car wheel flange. This is best effected by the use of rails with grooved heads, but where side-bearing rails or ordinary T-rails are used, the groove may be formed by the use of special grooved paving blocks or bricks along the inner side of the rails, as has been done on electric railways at Minneapolis, Minn., and South Bend, Ind. The use of cast-iron blocks to convert step rails into grooved rails, is a still more recent improvement.* Where asphalt is used, or where a macadam road has heavy traffic, a line of bricks or granite blocks (laid as headers) may be placed to form or protect the grooves for the wheel flanges. A similar plan may be adopted on heavy grades to prevent macadam paving from being washed out along the rail, one or two lines of brick being laid as stretchers along the outside of the rail head.

On electric railways the grades and curves may be considerably heavier than on steam railways, but for high-speed electric interurban lines it seems probable that the curves originally adopted are in many cases excessively sharp, and will have to be flattened to permit safe and efficient operation, speeds of 25 to 45 miles per hour being frequently reached on such lines. Curves of 75 to 150 ft. radius are used on suburban and country lines, but 300 to 350 ft. should be the minimum where high speeds are to be maintained. City lines have curves of 30 to 125 ft. radius, and sometimes these curves are transitioned. In Philadelphia, curves of 400 ft. radius have transition curves 60 ft. long, with an initial radius of 3,400 ft.; 33-ft. curves have transition curves running out to 180 and 368 ft. radius at the ends. These transition or spiral curves are now very generally adopted, not only for ordinary curves on outlying parts of the line, where cars run at high rates of speed; but also on sharp city curves, to eliminate the severe shock and swing caused by a car passing from the tangent to the curve. Special care must be taken in laying out curves to ensure easy riding and (on double track) to prevent any liability of cars striking when passing on a curve.

The widening of gage and superelevation of rails on curves call for special consideration on electric railways. It must be borne in mind that the width of tread of wheels for electric cars is much less than that of ordinary railway wheels, so that very little widening of gage can be made without unduly reducing the bearing of the wheel upon the inner rail. On sharp curves where guard rails are required (sometimes all under 500 ft. radius), the gage may be widened a sufficient amount (according to the width of the groove) to prevent the flange of the wheel from cutting into the tread of the outer rail. Some double-track electric cars have trucks 17 ft. 9 ins. c. to c.; truck wheel-base, 4 ft. 6 ins.; wheels, 33 ins. diameter; width of tread, 2¼ ins.; flanges, ⅞-in. deep and 1 in. thick; axles, 4½ ins. diameter. Terminal loops of 33-ft. radius have the gage widened ½-in., but no elevation is required as the speed is invariably slow. On curves up to 100 ft. radius, the gage may be widened ¼-in., but beyond that, standard gage is commonly used. The rules used for superelevation on steam railways do not give satisfactory results in these cases, owing to the much lighter weight of the cars, but curves of 250 and 300 ft. radius on high speed lines, are sometimes elevated 3½ to 4 ins., using a guard rail on the inside. In city streets, an elevation of 2 ins. can sometimes be obtained on sharp curves without undue interference with the paving, but curves at intersections can have little or no elevation. In Boston the rail is elevated for a speed of 15 miles an hour, where the street construction will permit of using the formula $E = (G V^2) \div (32.2R)$.

As to the grades, cable railways are operated having grades of 15 to 20%. Electric railways operate successfully on grades of 8 to 12%, while 5 to 6% grades are common. A list of heavy grades in several cities was given in our issue of May 18, 1899. Where very heavy grades are encountered, a counterbalance system may be used to assist cars in ascending and to control them in descending. Under the track is a conduit, with a cable connected to a heavy counterweight truck running on rails in another parallel conduit, the cable passing over sheaves at top and bottom of the grade, and suitable apparatus being used for taking up the stock. The car has a grip which seizes the cable, and in ascending it is counterbalanced by the weight running down the conduit, while in descending it has to haul the weight up the grade. This system is used on grades of 16% at Seattle, Wash., and St. Paul, Minn., and 14% at Providence, R. I. Such systems might well be more generally employed on grades of 10% and over, or the grades reduced, as runaway accidents on steep grades are of rather too frequent occurrence.

As to the motive power, the electricity is now universally generated at central stations and distributed by feeders to various sections of the line conductor, from which it is taken either by trolley poles on the cars, or in a few cities by contact plows touching conductors laid in underground conduits. Electric surface-contact systems are also in experimental use. Cable traction has been largely superseded by electricity, and is now little used, except under special conditions of very irregular profiles and severe grades. Various systems of traction by independent motors (operated by steam, compressed air, gas, oil, or electric storage batteries) have been brought forward from time to time, but comparatively few have been found at all practicable, and of these few only a small number are in use.

The rapid development of electric railways for suburban and cross-country service has introduced a serious danger in regard to grade crossings with steam railways. When lines of this character first began to be constructed, it was assumed that they would be quite harmless and might cross the steam roads with impunity. It very soon became evident, however, that from carelessness, accident or defective equipment cars would frequently become stalled on the crossing, or fail to stop when the gates were closed or flags displayed at the crossing, with the result that many very serious accidents have occurred and many more have been narrowly averted. The dangers become greater as the traffic and speed on the electric lines increased. The builders of these lines, however, have as a rule not yet realized these conditions, and in very many cases expend much time and energy in endeavoring to obtain authority to establish grade crossings, when they might better have exerted themselves in endeavoring to obtain an overhead or underground crossing, which can in many cases be done in the original construction without excessive cost.

Another source of danger, which is still greater than that incident to grade crossings, is the adherence to methods of operation which, while proper enough for the slow speeds practicable with animal traction are entirely unsuited to the conditions of operating electric cars which are capable of very high speeds. The double track electric roads (outside of city limits) are few, and consequently arrangements have to be made for cars to pass at sidings or turnouts. The schedules are variable, and discipline is lax among the crews and the dispatching staff. In many cases the crews simply have general orders to pass at certain sidings, and very soon acquire a habit of trying to "steal a switch" by running at high speed in the hope of reaching the next turnout before meeting the opposing car. When accidents of this kind happen, the blame is usually laid upon the motormen and conductors, but the real responsibility lies with the management which has failed to enforce proper methods of operation.

Wherever cars or trains are run at high speeds, no matter what the motive power may be, the traffic should be operated on the principles which long experience in the operation of steam railways has shown to be essential to safety. Apart from the incidental requirement of much stricter discipline among the crews of electric lines, there are two methods of operation open: (1) The dispatching system; (2) the block system (with either automatic signals or the train staff). The dispatching system is already in use on some lines, and is usually operated by telephone, the instruments being placed in locked boxes at the sidings, and conductors being furnished with keys. At each siding, or at other suitable points, the conductor calls up the dispatcher, and gets his orders, being also notified as to the whereabouts of opposing cars. Small signals may be attached to the boxes, by means of which the dispatcher can notify a motorman to call up the office for instructions.

As an example of the system of telephone dispatching, we may cite the practice of the Milwaukee Electric Railway & Light Co. All motormen on the interurban lines are required to communicate with the dispatcher at the central office before leaving terminal points. The dispatcher gives running instructions to the motorman for that trip, advising him at what sidings extra cars (if there are any on the line) are to be passed, and he may advise the motorman to call up the dispatcher at some intermediate point. If a car should get behind time and lose its right of way, the motorman must call up the dispatcher at the first siding and get further instructions. All motormen on the first trip out in the morning are required to call up the dispatcher from the ends of city lines, in order that he may know that regular service has been resumed and that the track and wires are in proper operating condition. They are likewise required to call in from the ends of all city lines on the last trip at night, so that if an extra trip should be necessary on any line, the dispatcher can give the necessary instructions. The entire system is kept under telephonic communication and control at all times, as fully as the trains of a steam railway are kept under telegraphic communication and control from their division points. The Milwaukee company's lines are now being equipped by the Stromberk-Carlson Telephone Co. with what is probably the most complete and extensive telephone dispatching system that has ever been undertaken by any electric railway company. It is proposed still further to extend the use of the telephone system in the operation of the city and interurban lines, as the railway company believes that this adds greatly to the safe and regular movement of its traffic.

If a block system is adopted, the train staff commends itself by its cheapness and simplicity for use on electric railways. Stopping to change the staff, moreover, is much easier than on main lines of steam railways. A block system for sin-

*Engineering News, May 23, 1901.

gle track electric railways which has been introduced on the Lowell & Suburban Electric Ry. (Eng. News, May 25, 1899), depends not upon signals, but upon actually cutting off the current from the opposing car by the car having the right of way. When a car leaves a turnout, it automatically shuts the current off from the turnout next in advance (on the side which an opposing car would take) and also shuts off the current from its own side of the turnout which it leaves. Various other systems, some simple and inexpensive, and others more elaborate, are in sufficient use to have shown their practicability, so that there is no real excuse for operating cars or trains on electric railways in such a manner as to endanger the lives of passengers and employees.

THE ACCIDENTS AT THE EAST SIDE WATER-WORKS INTAKE TUNNEL, CLEVELAND, O.

As was briefly noted in our last issue, the new water-works tunnel at Cleveland, O., was the scene of a disastrous accident on Aug. 14, which resulted in the loss of ten lives and considerable property damage. This accident occurred at Crib No. 2. On Aug. 20, Crib No. 3 of the same tunnel was partially wrecked by some cause not fully determined, and five men were killed. The following description of these two accidents has been prepared at our request by an engineer familiar with the work.

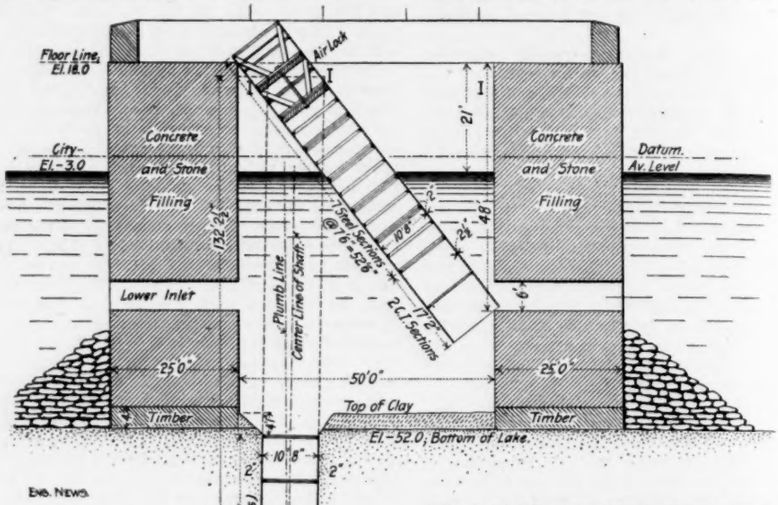
ACCIDENT AT CRIB NO. 2.—On Aug. 14, at 2.30 a. m., a fire broke out on Crib No. 2 of the East Side Tunnel, Cleveland, O., which completely burned the superstructure to the floor line, or 13 ft. above water level, leaving only the outer walls standing. The exact cause of the fire is not known, although the testimony of the workmen all tended to show that it was due to an overheated smoke-stack, which set fire to the roof, the flames spreading with such rapidity that five of the men were burned to death where they slept; the others, to the number of 26, were compelled to jump into the lake, some clinging to ropes caught over spikes in the side of the crib, and the most of them supporting themselves on plank which were thrown off the crib. Four men lost their hold and were drowned, and 22 were saved. Six of these were picked up by a boat from the steam barge "Wilhelm," which was coming down the lake with a barge in tow. On seeing the fire she dropped the barge and came on full steam, dropped her boat near the crib and picked up six men who were hanging to the side of the crib. About the same time the tug "J. R. Sprankle," in charge of Captain Thorne, arrived and picked up all the others, 16 in number.

This fire occurred just at a time when the stationary engineer on duty, and who was in charge of the crib, was down at the bottom of the shaft. He and the elevator operator came up on the elevator to within about 20 ft. of the top, but were then driven back to the bottom of the shaft by the flames and went into the west drift of the tunnel, where nine men were engaged in cleaning out the drift preparatory to building a new air-lock at the face of the work, or about 3,400 ft. from the shaft, after the completion of which they were to resume the work of building the tunnel in this heading to the intake crib; the distance between this heading and the inlet shaft being about 3,600 ft.

After the fire had been put out by the fire tug "Clevelander," the contractor's foreman went down the shaft and called out for the men in the tunnel to come on to the shaft. He found the air badly vitiated at the bottom, and came up quite exhausted. The men in the tunnel had been working at about 2,800 ft. west of the shaft, having cleaned up and removed all dirt and waste material to this distance from the shaft.

They were soon joined by the engineer and elevator operator, who, as before stated, were forced to recede to the bottom of the shaft by the flames and smoke descending into it, and after telling them what had occurred on the crib, they all then started for the shaft. When within a short distance of the place where the air-lock had formerly been located, they encountered afterdamp, which had forced its way down the shaft and into the tunnel. This soon overcame one of the men, and he was placed on one of the work-cars and pushed along by the other men until their strength threatened to give out, when he was left behind on the car and the rest made their way to the shaft. Men were then lowered down the shaft with ropes, and the men at the bottom were soon conveyed to the surface by the same appliance used in the lowering of the rescuing party. All of the men were conscious, except one man, and he was soon revived and taken ashore. The number of men brought up was eight, and they reported that there were three more men in the tunnel.

Air was then pumped into the tunnel by the fire tug, which turned off the sea-cocks connected with the pumps, and after pumping out the water in the bilge, pumped air through a 4½-in. hose which was lowered down the shaft and dragged in the tunnel to about 150 ft. west of the shaft by the rescuing party, consisting of the contractor's men, who were assisted by the captain and crew of the United States Life Saving Station at this port.



SECTION OF CRIB NO. 3, CLEVELAND WATER-WORKS TUNNEL, SHOWING MANNER OF ACCIDENT TO STEEL AND IRON SHAFT.

Attempts were made throughout the day to bring out the men remaining in the tunnel, and one of the rescuing party lost his life during one of these endeavors. In the afternoon the man who had been left on the car was rescued, brought up to the surface, and although apparently dead, he soon revived under the efforts of the life-saving crew to bring him back to life. The next trip brought up the body of the man who lost his life in heroically trying to rescue his fellow-workmen.

In making these trips from the shaft to where the man had been left on the car, the men making them found no sign of anyone else being in the tunnel, and the contractor's superintendent, as well as others on the crib, after questioning the men who had been rescued from the tunnel, came to the conclusion that there were no more men in the tunnel, and that the men must have made a mistake as to the number of men working in the tunnel at the time the fire occurred on the crib. Nothing was said by anyone that would lead one to believe that two of the men were left behind, or had become separated from the rest of the party. All the information received indicated that the man left on the car was the farthest in the tunnel from the shaft, and if others had been overcome, it would be between him and the shaft; and as no one was found in this part of the tunnel, it was concluded that all the men were out of the tunnel.

As all the machinery and boilers on the crib were destroyed or injured, the contractor then procured another boiler, which, owing to the unfavorable weather, could not be placed on the crib until Sunday, August 18. His intention was to fit up this boiler and overhaul one of the air-compressors which seemed to be in pretty fair condition, and as soon as possible pump fresh air into the tunnel through the pipe leading to the face of the work, and, as soon as it became safe, to send men into the tunnel and bring out the bodies of two mules which were known to be in there.

On the following day, or August 19, one of the men on the crib heard a faint rapping on the air-pipe extending from the top of the shaft to the face of the work, and on telling the foreman, he (the foreman) gave the regular signal on the pipe for calling men out of the tunnel, and got an immediate response—indicating that one or more persons had remained in the tunnel and were still alive. As soon as additional help could be procured a party of men were lowered down the shaft and only went a short distance into the tunnel when they came in contact with two men who were coming towards them. These men had been separated from the others at the time of the fire without their knowledge, and had gone back towards the face of the work. Upon being brought to the surface they exclaimed that there were still nine men in the tunnel, not being aware that the others had been rescued long before.

Work on the headings from this crib was shut down in December, 1900, and permission was asked this spring by the contractor to resume work at this crib and continue driving tunnel towards the inlet shaft. This was granted by the city, and the contractor then proceeded, as first stated, to clean up the tunnel and to move the air-lock. This not being construction work there was no City Inspector maintained on the crib.

When work was shut down last winter the fire pump, which had been placed on the floor of the crib for fire protection, was in its proper place. It seems, however, that when the contractor began the work of pumping the water out of the tunnel and cleaning out the drift, he moved this pump and set it up at the bottom of the shaft, without the knowledge of the city officials, leaving the crib entirely without fire protection. The removal of this pump from its proper position on the floor of the crib, and the absence of the engineer from his post of duty, is considered to be responsible for the disastrous fire and its terrible consequence. A description of this crib appeared in Engineering News Aug. 11, 1898.

The total number of lives lost in this fire is ten; five were burned to death, four drowned, and one lost his life in attempting to rescue his fellow-workmen. According to the terms of the contract, the contractor is obliged to take all reasonable precaution to protect the tunnel, shafts and cribs from any possible danger of damage of any de-

scription from floods, storms, tidal waves, fire, or any other cause, and must immediately repair any damages that may occur to the tunnel, shafts, cribs and lights, or any other structures or appliances required or used in connection with the building of the tunnel and shafts. He must assume all risk of every nature in doing the work, and shall be held liable for the safety of the cribs, shafts and tunnel to the amount paid for them by the city. In accordance with another provision of the contract, the contractor was notified to repair immediately all damage resulting from the accident, and upon his refusal to do so, the city has begun rebuilding the crib at the contractor's expense.

ACCIDENT AT CRIB NO. 3.—The second accident occurred at 7.30 p. m., Aug. 20, at the intake crib of the East Side Tunnel, known as Crib No. 3. The intake shaft on this crib had just been completed and the work of driving the tunnel from this shaft towards Crib No. 2 had been begun. The invert of the first section of tunnel was built up, and the men were just engaged in setting the ribs for the purpose of building the arch.

This shaft had been completed under air-pressure, the air-lock being situated in the second cylinder from the top, or about 17 ft. below the floor line of the crib. One man was in this air-lock and two men were on a platform immediately below the air-lock guiding a rib through the lower door, which was being lowered down to be placed in position by four men working at the bottom of the shaft. Without any warning whatever the upper portion of the shaft, about 69 ft. in length, broke away from the lower sections and, according to the account of the foreman on the crib, shot up about 10 ft. above the floor of the crib, then settled back and went up again, this time going up to the roof of the building on the crib about 24 ft. above the floor line.

The shaft was sunk on the north side of the well 50 ft. in diameter. In settling back, the bottom of this broken section of shaft swung out across the well of the crib and lodged in one of the lower inlet tubes on the south side of the well, opposite from the shaft, the top of the shaft resting on the bolster on the north side of the well, near the floor line, as shown by the accompanying cut.

Immediately after the shaft had settled back the foreman got down to the air-lock and opened the valve on the blow-off pipe, and, according to his account, exhausted the air in the shaft in about two minutes. In his opinion there was about 10 lbs. pressure on when he opened the valve. As soon as the air-pressure was exhausted the door was opened and they were able to rescue the men who had been in the air-lock, and one of the men who had been on the platform immediately beneath the air-lock. The other man who had been on the platform could not be found, although search for him was made down to the water's edge. He was hurled down the shaft and drowned. The two men rescued were not injured in any way. The four men who had been at work on the bottom of the shaft also lost their lives.

The services of a diver were procured and an examination made, which disclosed the fact that the break had occurred at the root of the lower flange of the ninth cylinder from above, or at a point about 4.1 ft. below the bottom of the well. This shaft was built of seven cylinders made with steel plates and cast-iron flanges, of a total length of 52½ ft., and below that seven cast-iron cylinders 60 ft. long resting on a brick underpinning consisting of four rings of brickwork, and extending 19½ ft. from the last iron cylinder to the bottom of the shaft. The total length of the shaft was 132 ft. 2½ ins. The shaft is made with internal flanges, the clear diameter being 10 ft. and the outside diameter being 11 ft. During the building of the shaft from 25 to 30 lbs. air-pressure were maintained, and at the time of the accident the gage only indicated 24 lbs. pressure. The total weight of the iron cylinders and the brickwork, which was secured to the cylinders by heavy iron rods, was about 342,000 lbs. The total lifting power of the air at 24 lbs. pressure was about 328,000 lbs. The shaft was also secured by four pine timbers, each 12 ins. wide and 14 ins. deep, extending across the top of the shaft and wedged up tight against the under side of the upper flange of the two heavy plate girders spanning the well and riveted to the inner shell of the crib. Some of the iron-work of the superstructure was bent and twisted, and will have to be replaced; but this damage is not serious.

Up to date no satisfactory conclusion as to the cause of this break has been reached. The contractor was given immediate notice to repair all damage done, and he has expressed his willingness to proceed with this work at once. The total loss of life in this accident was five men.

THE TRAFFIC THROUGH THE SUEZ CANAL in 1900 aggregated 9,738,152 tons and the transit receipts were $17,490,356. The mean net tonnage per vessel was 2,836 tons; the mean duration of passage for all vessels was 18 hrs. 32 mins.

THE POPULATION OF CANADA, by the census of 1901, is 5,338,883, an increase of 505,644, or about 10%, since 1891. The population of the principal municipalities in 1901, compared with smaller figures for 1891, are reported by press dispatches as follows:

	1901.	1891.		1901.	1891.
Montreal	266,826	220,181	Vancouver	26,196	13,709
Toronto	207,971	181,220	Brantford	16,631	12,753
Quebec	68,834	63,090	Hull	13,988	11,264
Ottawa	59,902	44,154	Charlottet'n	12,080	11,373
Hamilton	52,550	48,980	Valleyfield	11,055	5,515
Winnipeg	42,336	25,639	Sherbrooke	11,765	10,097
Halifax	40,787	38,495	Sydney	9,908	2,427
St. John	40,711	39,179	Moncton	9,026	5,165
London	37,983	31,977	Calgary	12,142	3,876
Victoria	20,821	16,841	Brandon	5,738	3,778
Kingston	18,043	19,263			

REVIEW OF MARINE ENGINEERING DURING THE LAST TEN YEARS.*

By James McKechnie.†

(With two-page plate.)

The choice of the subject of this paper is due to the fact that at the beginning of each of the three past decades a paper has been contributed to the Institution reviewing the progress of marine engineering. A similar review is appropriate now at the beginning of a new century, when there is a general tendency to erect mile-stones marking the stages reached in each branch of science.

FUEL ECONOMY.—As the engineer cannot ignore the dictates of finance, progress must primarily be measured from the standpoint of economy. A steamship is built to carry a given load of passengers, or of material, for a given distance; and success is reckoned according to the expense incurred in doing this work. The engineer's part is considerable, and is largely associated with fuel economy and repairs, as well as with first cost. It can scarcely be said that the development during the past decade has been so marked, so far as fuel economy is concerned, as that in immediately preceding decennial periods; largely, because each successive attainment necessarily involves relatively greater effort. In 1872, the coal consumption was recorded as 2.11 lbs. per unit of power per hour; by 1881 it had been brought down to 1.83 lbs.; in 1891, when the triple expansion engine had come into almost universal use, the rate became 1.52 lbs.; and now, a careful analysis shows that the average for new ships with the latest equipment is about 1.48 lbs.

TABLE I.—Comparison of Marine Engines for the Years 1872, 1881, 1891, 1901.

Boilers, engines and coal.	Average results. 1872.	1881	1891.	1901.
Boiler press., lbs. per sq.in.	52.4	77.4	158.5	197
Heating surface,* sq. ft.	...	30.4	31.0	38 & 43†
Heat'g surf.,pr I.HP.,sq.ft.	4.41	3.917	3.275	3.0
Coal, sq. ft. of grate, lbs.	...	13.8	15.0	18 & 28†
Revolutions per minute	53.67	59.76	63.75	87
Piston speed, ft. per min.	376	467	529	654
Coal per I. HP. pr hr., lbs.	2.11	1.83	1.52	1.48
Av. consumpt'n, long voyage	...	2.0	1.75	1.55

*Per sq. ft. of grate. †Natural and forced draft respectively.

In determining coal consumption, actual performances at sea should be taken rather than trial-trip results, as seems to have been the case in preceding papers; and thus the coal consumption of 1881, instead of being 1.8, should rather be 2 lbs. or 2.1 lbs., for the mean consumption of 12 steamers built in 1878-'80, and fitted with compound engines, on voyages aggregating 340,000 miles, works out to 2.1 lbs. per HP. per hour. Again, the coal consumption of 1891 was given as 1.52 lbs.; but the sea record of ships built then show a consumption of between 1.75 and 1.8 lbs., as recorded in a comparison of performances between Liverpool and Grand Canary, voyages which occupy about a week, and represent each from 1,400 to 1,700 miles steaming. Some little allowance, however, should be made in this case for the coal used for pantry and heating purposes during the voyages. Thus it may be said that in 1881 the average consumption at sea was 2 lbs. per HP. hour; in 1891 1.75, and now about 1.55 lbs. Upon the sea performance the saving to-day is about one-fifth of a pound per HP. per hour as compared with 10 years ago; and about ⅛-lb. as compared with 20 years ago—a result which is the more satisfactory when it is borne in mind that it has been attained without multiplying the working parts of the engine, or so increasing the delicacy of the machinery as to involve a higher skilled labor in its management on shipboard.

The increased economy is partly due to the higher steam pressures now in use. In 1891 the average was about double that of 1881, and now the increase is from 158 to 197 lbs. per sq. in., the average for 45 ships with triple expansion engines built within the past nine months being 180 lbs., and for nine steamers with quadruple expansion engines 214 lbs. In former years, naval machinery was included in the reckoning, the conditions being similar to those obtaining in the merchant service; but now, with the adoption of water-tube boilers, the practice is dissimilar, and naval ships are not considered in determining this year's averages. As a result of the higher steam pressure and more economical engines, more power is obtained from the boilers per sq. ft. of heating surface, the average per I. HP. having in ten years decreased from 3.275 to 3 sq. ft. At the same time the piston speeds of engines have considerably increased. The average, ten years ago, even including warships, has now become the mean rate for the tramp steamer—530 ft. per minute, while many steamers for high speed attain to 880, a few to 950 ft.

ECONOMY PER 100 TON-MILES OF LARGE CARGO CARRIERS.—Improved economy in the oversea transport of commerce is also being sought for now in the greater size of cargo steamers, the fuel consumption of which does not increase in the same ratio as the cargo capacity. This point is illustrated in the diagram, Fig. 1, which shows the coal consumption per 24 hours for each 100 tons of cargo carried in vessels of progressive size, each steaming 13 knots. The particulars of the various ships upon whose performances this diagram has been based, are set out in Table II. It will be seen in the first place that the weight of the ship itself does not increase in quite the same proportion as the cargo capacity, the immerse area increases at a slower rate than the load displacement, and the power necessary for a given speed advances at a corresponding lower ratio. Thus, a ship to carry only 5,000 tons requires machinery of 3,475 I. HP. to propel her at 13 knots; while, in the case of a ship of treble the capacity, the power is scarcely double. In other words, the consumption of coal per hundred ton-miles in a now relatively small ship taking 5,000 tons of cargo, is 8 lbs., while the vessel taking 16,000 tons uses only 4.4 lbs. per hundred ton-miles, the rate of consumption per unit of power per hour being assumed in all cases at 1.5 lbs. Not only is the fuel consumption less, but the first cost per ton carried need not be greater, and the working expenses generally are lower, because mechanical means are introduced more freely for many purposes, while the personnel does not increase pro rata with size.

This greater economy is the cause of the steady growth in the size of ships. The total number of vessels of over 10,000 tons in existence ten years ago was 2; now there are 51, of which 10 are over 13,000 tons. Ten years ago there were only 91 vessels which exceeded 5,000 tons register; at the end of last year there were 505. The distribution of these vessels in point of tonnage and of nationality, shows that the higher economy of the larger ships is being widely recognized. Germany maintains her position with Britain so far as large ships are concerned. But these are questions of general policy; details as to the problems involved in the attainment of economy are of more importance.

STEAM PRESSURES AND BOILER TESTING STANDARDS.—The author naturally begins with steam genera-

*Slightly condensed from a paper read before the Institution of Mechanical Engineers of Great Britain, July 31, 1901.

†Barrow-in-Furness, England.

TABLE II.—Particulars of Cargo Steamers for North Atlantic Trade, to Illustrate Fuel Economy of Large Capacity Ships. (All are three-decked vessels, with shelter deck, to Class 100 A1 at Lloyd's.)

Dimensions.	Draft. ft.	ins.	Displacement, tons.	Co-efficient of displacement.	Dead-w'ght, tons.	Speed at sea, knots.	I. HP.	D. ⅜ constant.	Immersed Area, sq.ft.	Immersed Girth, ft.	Coal: 100 ton-miles,* lbs.
390′ × 45′ 9″ × 29′ 6″	24	6½	8,640	0.69	5,000	13	3,475	266	1,092	87.8	8.0
415′ × 48′ 9″ × 31′ 0″	25	6	10,240	0.696	6,000	13	3,725	277	1,209	92.46	7.1
438′ × 51′ 5″ × 32′ 8″	26	3½	11,870	0.702	7,000	13	3,970	287	1,314	96.46	6.5
458′ × 53′ 9″ × 34′ 0″	27	0½	13,500	0.71	8,000	13	4,225	295	1,412	100.0	6.05
475′ × 55′ 9″ × 35′ 5″	27	11	15,100	0.715	9,000	13	4,475	300	1,513	103.64	5.7
493′ × 58′ 0″ × 36′ 7″	28	7	16,750	0.72	10,000	13	4,725	305	1,610	107.0	5.42
521′ × 61′ 2″ × 38′ 9″	30	0	19,850	0.728	12,000	13	5,200	311	1,780	112.8	4.97
535′ × 62′ 9″ × 39′ 9″	30	7	21,470	0.732	13,000	13	5,430	313	1,862	115.4	4.8
548′ × 64′ 1″ × 40′ 9″	31	3	23,070	0.736	14,000	13	5,675	314	1,946	118.0	4.66
570′ × 66′ 9″ × 42′ 4″	32	4½	26,150	0.742	16,000	13	6,130	316	2,097	122.5	4.4

*The rate of coal consumption is assumed in all cases at 1.5 lbs. per I. HP. per hour.

tion and if will no doubt conduce to the general harmony if the subject of the water-tube boiler is not dealt with. It would demand too much time; the question is more or less sub judice, and its consideration in any case would involve a protracted discussion, perhaps without direct value, as there are very few engineers who can boast that they have not taken out a patent for a wafer-tube boiler. There is enough in connection with cylindrical boilers as well as with machinery practice generally upon which a free expression of opinion is desirable. There has come within the past ten years some uniform degree of practice as regards cylindrical boilers. There is generally a preference for the single-ended type, although convenience often requires the adoption of the double-ended boiler; but the through combustion chamber is a thing of the past. It has already been pointed out that the pressure for 45 ships fitted with triple expansion engines within the past nine months averages 180 lbs., while in the case of nine steamers with quadruple expansion engines it averages 214 lbs., the maximum attained with cylindrical boilers for merchant practice being 267 lbs. In the naval service steam pressures of 300 lbs. are now quite common with water-tube boilers. There is thus an increase on the average in merchant steamers of about 25% and in naval practice of 100% as compared with ten years ago.

If would seem as if the limit was being reached with tank boilers, because in the case of the boiler to work at 267 lbs. the shell plates are $1^{15}/_{32}$ ins. thick, although the diameter is only 13 ft. The boiler illustrated in Fig. 2, for the "Ortona," built at the Naval Construction Works at Barrow-in-Furness, is probably as large as any yet constructed, the diameter being 17 ft., and here the shell plating is barely so thick as that of the boiler already referred to; but, on the other hand, the steam pressure is only 190 lbs. Ten years ago there was a strong desire that the Board of Trade and Lloyd's might reconsider the ratio of test pressure to the working pressure, but it still continues to be double. The Board of Trade have accepted shell plates having a tensile strength of 29 to 32 tons per square inch, but the margin here between maximum and minimum is very small, and each plate must be tested by the surveyor. The material test is the same as ten years ago, i.e., from 27 tons to 32 tons. Prior to the adoption of the water-tube boiler, the Admiralty practice was to test the boiler up to 90 lbs. over the prospective working pressure, and in this case the test pressures for the boiler for the "Ortona" would be 280 lbs. instead of the Board of Trade standard of 380 lbs. Advantage could thus be secured in decreased scantlings. For instance, the shell plate under the Admiralty rule would be $1^{7}/_{16}$ ins. thick, instead of $1^{9}/_{16}$ ins. The stays would also be reduced $\frac{1}{16}$-in. in diameter, becoming 3 ins. and $3\frac{1}{4}$ ins. The scantlings of the remaining parts would remain about the same, with the exception of the furnaces which are invariably of greater thickness in the Admiralty tank boilers. The relative stresses, factors of safety and tensile strength of material are as follows:

Stress on steel stays in steam space:

Board of Trade—Working pressure	9,000 lbs.
At test	18,000 "
Admiralty—At working pressure	10,400 "
At test.	18,000 "

Factor for Shells.

Board of Trade.....4.5 Admiralty.....3.9

Tensile strength of material:

Board of Trade—20 to 32 tons per sq. in., with minimum elongation of 18% in 10 ins.

Admiralty—27 to 30 tons per sq. in., with a minimum elongation of 20% in 8 ins.

It will thus be seen that for a given diamefer there is, with the Admiralty rule, a possible saving in weight, or alternatively the diameter within reasonable limits of prudence may be increased, regard being had to the thickness of shell plating that may be deemed practicable. At the same time, it is a matter for consideration whether the differences in the rules as to boiler scantlings enforced by government department and underwriting associations should not be carefully examined with the view of determining some uniform standard, for while in the case of the Bureau Veritas the pressure permissible for given conditions is 5% less than with Lloyd's, the U. S. Board of Survey permits about 20% higher pressures.

BOILER DRAFT AND EVAPORATION.—The closed stoke-hold system is seldom resorted to now, the preference—particularly in the merchant service—being in favor of heating the air supply before it reaches the furnace, either by a closed ashpit forced system, as in the Howden arrangement, or with an induced draft. In both cases heat is got from the waste gases. The horsepower of ships fitted with the first mentioned heated draft system is 3,406,000 I. HP., and there can be no doubt that very economical results have been achieved. With this system of draft it is possible to burn more coal per square foot of grate and to obtain a higher evaporation per square foot of heating surface. The average ratio of heating surface to grate area in the case of 30 forced draft steamers built within the last nine months is 39.29. Two or three of the vessels were designed for particular trades and special fuel for which large grates are needed; but taking ordinary steamers, the ratio probably averages 42 to 43 sq. ft. for forced draft, while with natural draft the average, also for 30 steamers, is 38.3. Ten years ago the mean for 28 steamers was 31 sq.ft., and 20 years ago the mean of 39 steamers was 30.43 sq. ft.; so that it will be seen that the modern cylindrical boiler has 30% more heating surface per square foot of grate.

The coal burned per square foot of grate is 1881 was 13.80 lbs. and in 1891, 15 lbs.; it now averages with natural draft 18 lbs., and with forced draft as high as 28 lbs. Finally, the heating surface allowed per HP. is 3 sq. ft. as compared with 3.275 ten years ago, and 3.91 twenty years ago. The increase in steam pressure and other changes has enabled the power per ton of boiler to be considerably increased, 16.5 I. HP. per ton including fittings now being attainable in cargo steamers, 20 I. HP. in passenger steamers, 30 I. HP. in high speed channel steamers, and 23 I. HP. in Atlantic liners.

OIL FUEL.—It can scarcely be said that much progress has been made in the general application of oil fuel, although it confers great advantages in uniform and easily regulated stoking. Nearly all oil tank steamers now use liquid fuel; but few general traders have adopted the system. The disadvantage of greater cost of oil is diminishing, owing to the increasing price of coal and a more plentiful supply of oil; but apart from this, there is the slightly greater prime cost of the ship with its more carefully built bunkers to store the oil fuel. In the construction of a petroleum steamer all bulkheads require to be oil-tight, and no difficulty is therefore experienced in making the bunkers similarly tight. Even if the oil were carried in the double-bottom and water-ballast tanks, it is estimated that the care in construction and difference in structure adds $10,000 to the cost of a moderate sized ship. Oil, when water charged, involves difficulties, although separators may partly overcome these. These objections are not insuperable, and moreover, a high degree of perfection has been attained in burner appliances; but there is still wide difference of opinion as to whether the mechanical spray, the steam or air-propelled jet, or the volatilized system proves most efficient. The first requires brick lining to maintain the initial furnace temperature; the steam spray involves a loss of fresh water which has to be made up by the evaporators, and the fuel thus used is equal to from 2 to 3 cwts. per day in a 1,000-HP. ship; with air the steam necessary for the compressors also involves fuel consumption, but the quantity is less than that necessary for making up the water lost by the steam spray. The boiler evaporation is probably from 12 to 15 lbs. of water from and at 212° per pound of fuel, and even more is claimed in some cases.

The use of volatilized oil seems to offer great advantages; it is vaporized by being first heated and subsequently distilled in the presence of superheated steam within a retort burner, and in this case the evaporation is probably slightly higher, without any initial heat expenditure of great extent. But, after all, it seems still a question of relative price of coal and oil, so far, at least, as slow steaming is concerned. In naval practice difficulties have been experienced in securing the same amount of steam with oil fuel from water-tube boilers as is commonly obtained with coal. On a three hours' trial as much as 90 lbs. of coal has been burned per square foot of grate, and it has thus far been found impossible to approach this result economically with oil fuel. In fact, the maximum power obtained with oil in the Admiralty experiments in the "Surly" with small tube boilers is less than half that obtainable with coal. When burning the oil beyond a certain rate dense volumes of smoke are formed; but with that progressive spirit which has been characteristic of the engineering branch of the service during Sir John Durston's regime, tests are being continued with the view of determining the best method of utilizing the special advantages of the oil fuel. As an auxiliary to coal, and burned in conjunction with it, the advantages appear to be considerable; but in any case there are special risks attending its use on board warships, as the recent grounding of a German vessel demonstrated. In this case the oil fuel was liberated and caught fire, causing more damage than the actual grounding.

MECHANICAL STOKERS.—Mechanical stokers are now widely adopted in connection with land boilers, but there are probably only two or three cases where a similar system is adopted on board ship although there seems a wide field for them, especially if the water-tube boiler with its large grate is likely to come into favor for merchant as for naval practice, because frequent and uniform distribution of coal on the grate is necessary to complete combustion. The system fitted in one or two of the American lake steamers for stoking water-tube boilers is of the chain type, and does not differ materially from the general run of mechanical stokers operated on land. On official trials this stoker gave satisfactory results, the consumption being 33.64 lbs. of coal per sq. ft. of grate and 1.998 lbs. per HP. hour; while at 20.62 lbs. per sq. ft. of grate, the rate was 1.56 lbs. per HP. hour. At the Naval Construction Works at Barrow a stoker for marine use is at the present time being tested, but the results are not yet conclusive.

SUPERHEATING STEAM.—At the moment the aim not only of the naval, but of the merchant marine engineer, is to secure higher steam pressures, because upon them largely depends increased economy, and at the same time there is probability of a development in the direction of the use of superheated steam. In this way, the waste heat may be further utilized in the uptake as with forced draft. Indeed, on a short trial with vessels so fitted, the steam being superheated to the extent of 57½ F., and the pressure being 267 lbs., the rate of fuel consumption worked out at 1 lb. per HP. per hour; but a possible danger to be strictly guarded against is the multiplication of parts, especially if located in positions difficult of access when the vessel is under way. Where a premium is not given for fuel economy or where it is not generally divided by the ship's captain amongst the engineers, there is a probability that where the gear is in such warm corners the tendency will be to shirk periodical inspection. These remarks must be accepted in their general sense, and not as specially applied to the case in point; for credit is undoubtedly due to the promoters of this modern superheating arrangement.

THEORETICAL ECONOMY OF HIGH STEAM PRESSURES.—If may not be without interest to show diagramatically the theoretical advantage which may accrue from the use of high steam pressure. In plotting the curves shown on Fig. 3, a terminal pressure of 15 lbs. and a back pressure of 3.5 lbs. have been assumed, while the expansion is that of perfect gas (hyperbolic). The lower curve shows the percentage of gain above 100 lbs. for the mean pressure which is represented by the upper curve. Thus with steam at 100 lbs. pressure the theoretical mean pressure would be 42 lbs. per sq. in.; but with a pressure of 300 lbs. the mean becomes 57 lbs., so that the gain as compared with 100 lbs. steam is shown to be 35.7%. It will be observed that the gain does not increase in the same ratio as the pressure.

Generally it seems doubtful whether a great advantage can accrue from the use of quadruple compounding until the initial pressure is at least 220 lbs.; and thus it comes that the practice of adopting four-stage expansion has not developed to the extent that was anticipated ten years ago. Of the new steamers added to Lloyd's Registry during the past nine months, only some 3% are fitted with quadruple expansion engines, and it can scarcely be said that this is due to reluctance to multiply working parts, because the practice of adopting four cylinders and four cranks for three-stage expansion has become very general in passenger steamers, even with pressures of 200 lbs.

SOME DIFFICULTIES OF HIGH STEAM PRESSURES: PIPE JOINTS AND FLANGES.—But before entering upon the question of cylinder arrangement attention may be directed to some of the difficulties which have arisen owing to the use of high steam pressure, especially in connection with the joints for steam and feed pipes—difficulties which have been overcome in naval ships, and which should therefore be studied by those engaged in merchant practice. In the first place, the higher steam pressure has necessitated several changes in the material used. Solid drawn and lap-welded steel tubes are now used in place of copper pipes, and for large valve boxes and bends gun metal is sometimes used; but cast steel would be used wherever possible and more extensively, if casting as thin as considerations of strength would determine could be produced by steel makers. The full use of this material is this country is retarded by the apparent inability to produce sound thin castings.

In the earlier warships, with huge steam pressure machinery (260 lbs), all the steam pipes over 3 ins. in diameter are of steel; in the later vessels with 300 lbs. pressures, the same material is used for all pipes over $1\frac{1}{2}$ ins. diameter. Such steel pipes up to 6 ins. in diameter are solid drawn with weldless steel flanges screwed on, while those over this size are lap-welded with a butt strap covering the weld, the flange being carefully riveted on. It was found possible to bend the steel pipes up to 4 ins, and it is to be hoped that progress will be made in this direction so as to reduce the number of expansion boxes. The higher pressures also involve change in connection with joints; and many experiments have been made. The diagrams (Figs. 4 to 7) illustrate some types as applied in successive cruisers. Fig. 4 shows the steel flanges fitted to the steel steam pipes of H. M. S. "Powerful." In this example the surfaces are only machine finished, the actual joint being made by a soft copper ring of triangular cross section. This system gave very satisfactory results under water tests, but a few months' actual use brought about such pitting of the steel faces, due to galvanic action, that the joints would no longer keep tight. Another objection to the system was the dropping of the ring owing to its loosening as a consequence of the expansion and contraction of the line of pipe, and its being thus free to take a position eccentric to, and crossing the edges of, the bore. To overcome this the rings shown in Fig. 5 were substituted in H.M.S. "Amphitrite," in conjunction with a recess formed in each flange, to prevent the ring dropping too far out of place. This effected some improvement, but the trouble from corrosion unavoidable with copper and steel in contact led to the system being discarded in favor of the form shown in Figs. 6 and 7. Fig. 6 shows a steel pipe joint with steel flanges, Fig. 7 a copper pipe joint with brazing metal flanges. Both are finished by handscraping, and the only material on the joint is a thin wash or paint of red lead and oil. This system has been adopted throughout H.M.S. "King Alfred," now building at Barrow-in-Furness. The author is of opinion that a simpler, cheaper and efficient form of joint could be used in place of the hand-scraped flanges, viz., a joint made with asbestos paper (about the thickness of brown paper) soaked in oil, the faces of the flange

being only machined, with no scraping. Indeed this material was adopted in several instances in the feed discharge pipes in which the pressure is over 600 lbs. per sq. in., the joints requiring to be re-made at sea.

ARRANGEMENT OF ENGINE CYLINDERS.—It may be said that so far as high-speed machinery is concerned, the universal practice is to fit a four-crank engine operated from four cylinders, usually on the three-stage compound system, and occasionally for quadruple expansion, the cylinders being arranged on the Yarrow-Schlick-Tweedy system. Ten years ago the greatest power developed in any steamer was 20,000 I. HP., and the highest speed on an over-sea voyage 20.7 knots. Now, 30,000 I. HP. is the highest in naval practice, the speed being 23 knots, while in merchant practice over 36,000 I. HP., has been developed, the mean speed on a trans-Atlantic passage being 23.51 knots, while at the present time there is building a steamer to excel this splendid result. Full

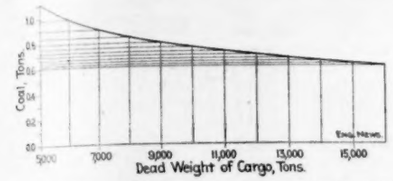


Fig. 1. Diagram Showing the Amount of Coal Required to Propel 100 Tons of Cargo at 13 Knots Speed for 24 Hours in Vessels of Various Deadweight Carrying Capacity.

credit for this remarkable speed should be given to the company who built the vessel, the Stettiner Maschinenbau Actien-Gesellschaft "Vulcan" of Stettin, who have built for German owners the two fastest merchant vessels afloat and are now building two to be at least equal in speed.

The low-pressure cylinder was only occasionally divided ten years ago, and the greatest diameter was 113 ins. In the case of the "Campania" such a division was made, and although the power was nearly 50% greater than in the ship with the 113 ins. low-pressure cylinders, the diameter of the largest cylinders was only 98 ins. Experience has shown the enormous importance of balancing forces in the reducing of vibration, so that there has been a further encouragement to divide the third stage or fourth stage cylinders; always provided that tandem cylinders are arranged in couples to balance each other. In this way, even although the power has reached in one set of engines 18,000 I. HP., the largest cylinders is only 106.3 ins. against the 113 ins. in the 10,000 I. HP. engine of ten years ago; the relative steam pressures being 220 lbs. and 150 lbs. Larger diameters are certainly not desirable, but there is no reason why with higher steam pressure a larger number of expansions should not be adopted with multiple cylinders, because any increase in the number of cranks tends to decrease the vibration.

CYLINDER RATIOS.—With increased steam pressure there has come a general increase in the average ratio of low-pressure to high-pressure cylinders. Ten years ago, when the steam pressure was about 158 lbs., the average ratios for 28 triple expansion engines were as follows:

$$\frac{\text{L.-P.}}{\text{H.-P.}} = 6.77, \quad \frac{\text{I.-P.}}{\text{H.-P.}} = 2.56, \quad \frac{\text{L.-P.}}{\text{I.-P.}} = 2.64.$$

With an average working pressure of 180 lbs., the mean ratios for 45 triple expension engines built within the past nine months are:

$$\frac{\text{L.-P.}}{\text{H.-P.}} = 7.55, \quad \frac{\text{I.-P.}}{\text{H.-P.}} = 2.74, \quad \frac{\text{L.-P.}}{\text{I.-P.}} = 2.76.$$

There is some variation in practice in the ratios of L.-P. over H.-P., but the great majority of the cases are within one decimal point of the average—7.55, but in the case of the other two cylinder ratios the variations from general practice are more marked. Generally in fast passenger steamers for the Channel service, where the runs are comparatively short, the conditions approximate to those in torpedo-boat destroyers, where reduction of weight is more desired than economy of fuel. And thus in the Channel steamers, with from 160 lbs. to 180 lbs. boiler pressure, the ratio of L.-P. over H.-P. is from 5.25 to 5.93. In steamers where coal economy is of importance, as is the case with large passenger liners and cargo boats generally, higher pressures have hardly brought proportionate change in ratio, the view accepted being that a large ratio of expansion is not not necessary, or even helpful to propulsive efficiency, when everything is considered from fire bars to propeller. With triple expansion engines for cruisers there has been an increase consequent on higher steam pressure. In the earlier high pressure cruisers using 210 lbs. steam, the ratio of L.-P. to H.-P. was 5.66, whereas with the 155 lbs. steam in former ships with cylindrical boilers the ratio was 5. In later ships, with 250 lbs. pressure, it has been increased to 7.1. Turning to quadruple expansion engines, the ratio of L.-P. to the H.-P. ranges higher than in the case of merchant steamers with triple expansion engines using the same steam pressure. In the case of 20 quadruple expansion engines built recently the ratios are:

$$\frac{\text{L.-P.}}{\text{H.-P.}} = 10.25, \quad \frac{\text{2d I.-P.}}{\text{H.-P.}} = 4.40, \quad \frac{\text{1st I.-P.}}{\text{H.-P.}} = 1.96$$

It certainly would be useful to have an authoritative series of tests on this question, and on its bearing upon economy, but it is difficult, if not impossible, in ordinary sea working to approximate the same conditions in similar ships, eliminating other variants in order to arrive at a definite conclusion on one such element. Data, however, might be collated say from some of the fair-sized experimental engines in college laboratories, a notable one being that in the Durham University College of Science at Newcastle-on-Tyne. Such results as have been published regarding its experimental working seem to show that for both triple and quadruple engines the total number of expansions may be kept comparatively low for true useful horse-power efficiency, that consequently the cylinder ratios may be kept small, and that the late cut-offs and consequent drops in receiver pressure so produced can be definitely determined to be of such value as to give the maximum economy, not necessarily on the basis of steam consumption per I. HP., but rather on the steam consumption per efficient HP. per hour.

STEAM JACKETS OF CYLINDERS.—With higher steam pressures and particularly with superheated steam, the necessity for steam jacketing in the high-pressure cylinders at least is not so great; but there are few cases in first-class practice where the jackets are not so fitted, although generally in ordinary marine practice liners are fitted in the cylinders to ensure a hard close-grained rubbing surface, but very often steam is dispensed with in the jackets. Recent trials with H.M.S. "Argonaut" showed that better results were got without using steam in the jackets, and the same result was shown in some more recent trials with the machinery of H.M.S "Hyacinthe," made under the supervision of the Water-Tube Boiler Committee. In the slow running engines of the merchant service, having an early cut-off, jackets are still found to be beneficial, but only to a limited extent; and there can be no doubt that as pressures increase, the use of steam in jackets will be dispensed with.

SLIDE-VALVE RELIEF-RINGS.—The changes which experience with higher steam pressures have necessitated in the design of slide-valve relief-rings for intermediate and low-pressure cylinders are shown in Figs. 8 to 15, the rings being illustrated as mounted on the slide-valve casing doors. Figs. 8 to 10 represent rings as fitted for the I.-P. and L.-P. slide-valves of naval engines with a steam pressure of 155 lbs. per sq. in., as was usual prior to the adoption of the water-tube boiler. In Fig. 8 the ring A which bears on the back of the slide-valve is of bronze, and steam is prevented from passing around the back of it by the two rings of rubber-centered asbestos packing shown behind it and kept pressed against the walls of the recess by the springs acting through the beveled rings. In Fig. 8 a Ramsbottom ring is substituted for the asbestos rings. Fig. 10 is packed by Ramsbottom rings, but an improvement is effected on the system shown in Fig. 9 by the application of tap-bolts forming an adjustable abutment for the springs. This enables the pressure of the ring against the valve and of the valve against the face to be varied. In Fig. 11, which is an arrangement fitted to an engine working with steam at an initial pressure of 220 lbs., this adjustment was not fitted, although the example is more recent than to Fig. 10, but the engines to which they were supplied were of very light type.

Figs. 12 and 13 illustrate the arrangement in use in the engines of naval vessels, where boiler pressure is 300 lbs. The former, Fig. 13, is an early example of the Vickers ring system which has given very satisfactory results. In this case steam is prevented from passing by metallic packing rings of wedge-shaped sections. The load is adjustable by tap-bolts and washers as in Fig. 10, but the addition is made of a stop to prevent the valve from lifting off its face more than will allow any accumulated water to be safely forced out of the cylinder. Fig. 13 is a later and improved form developed from Fig. 12. The earlier design, Fig. 12, suffered through having to be made to suit the casing covers. In the later arrangement the cover was designed to suit the rings, and thus a better form of ring was made possible. The tail of the spring-pad piece is clear of the bottom of the hole in the end of the adjusting tap-bolts, so that the valve can lift from its face as in the other examples, the amount of lift being limited to any desired amount by other long tap-bolts fitted at certain points on the same pitch circle as the spring adjusting bolts.

Figs. 14 and 15 are examples from recent mercantile marine engines working with steam of an initial pressure of 200 and 175 lbs. per sq. in. The later of these two arrangements embodies the metallic packing devices used in recent naval practice.

PISTON SPEED.—Reference has already been made to the increase in piston speeds; in the case of fast ocean-going steamers, as well as in naval ships, there has been a marked increase. The following table gives the speeds for the various types:

	Speed, per min.	Stroke, ft.
Ocean-going pas'g'r-steamers of high speed	950	5½
Intermediate ocean-going steamers	750	4½
Cargo steamers	530	4
High-speed cross-channel steamers	880	2¾

High pisfon speeds necessitate more attention being given to the lubrication of large working parts, especially of the lower parts of the crank and main bearing brasses. Advantage has been found to accrue from the grooving of the bottoms as well as the tops of all crank main and crosshead brasses, as it ensures free circulation of the lubricating oil. It can scarcely be said that a large proportion of recent accidents or breakdowns have been due to high speed of rotation, care in selection of the materials of construction and in the design of working parts having reduced to the minimum the chances of failure, while at the same time inspiring those in charge of machinery with increasing confidence.

THE DIAMETER AND STRENGTH OF SHAFTING.—There have been frequent failures of tail-end shafts, which have led the various registries to modify their rules in the direction of a greater margin of safety, while special recommendations have been made to prevent corrosion in the stern tube; but it may suffice to give a fable showing the increase in size of shafts required by the various registries. In Table III. the sizes are worked out for a three-crank vertical triple expansion engine having cylinders 23 ins., 38 ins., 63 ins. diameter and a stroke of 45 ins., the working steam pressure being 180 lbs. per sq. in.

TABLE III.—Showing Comparative Diameters of Shaft for an Engine of the Same Power in 1890 and 1900 by Various Authorities.

	Diameters of—							
	Crank shaft.		Thrust.		Tunnel.		Propeller.	
	1890, ins.	1900, ins.	'90, ins.	'00, ins.	'90, ins.	'00, ins.	'90, ins.	'00, ins.
Lloyd's	11¾	12⅜	11⅝	12⅜	11¼	11⅝	11⅝	13
Board of Trade	11⅞	11⅞	11⅞	11⅞	11¼	11¼	11⅞	12½
British Corporat'n.	11⅜	12⅜	11⅜	12⅜	11¼	11⅝	12⅜	12¾
Bureau Veritas	12⅛	12½	12⅛	12½	11⅞	12	12⅛	14⅛

The percentages of increase in the strength of the above shafts made to existing rules as compared with the rules dated 1890, are as follows:

	Crank shaft.	Thrust shaft.	Tunnel shaft.	Propeller shaft.
Lloyd's	17%	17%	14%	38%
Board of Trade	0	0	0	16.5%
British Corporation	17.5%	17.5%	14%	9%

STRESSES UPON MATERIALS IN CARGO STEAMERS' VERSUS TORPEDO-BOAT DESTROYERS' ENGINES.—While dealing with the subject of the strength of materials it may not be without interest to indicate

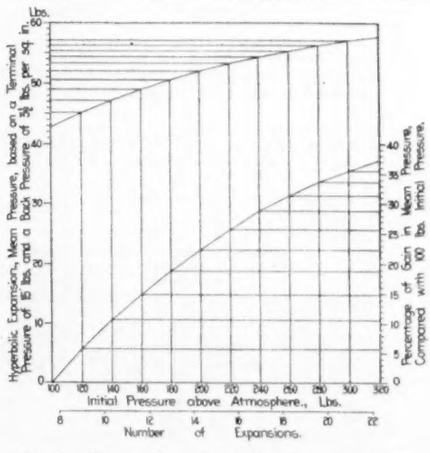

Lbs.
Hyperbolic Expansion, Mean Pressure, based on a Terminal Pressure of 15 lbs. and a Back Pressure of 3½ lbs. per sq. in.
Percentage of Gain in Mean Pressure, Initial Pressure, Compared with 100 lbs.
Initial Pressure above Atmosphere., Lbs.
Number of Expansions.

Fig. 3. Diagram Illustrating the Theoretical Economy of High Steam Pressures.

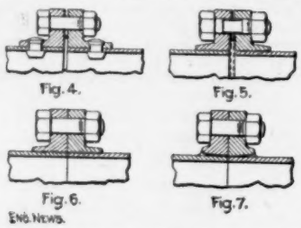
the extremes met with in modern marine engineering practice, as exemplified by the case of modern cargo steamers' engines, and the propelling machinery of a 30-knot torpedo-boat destroyer. In Fig. 16 there is given a contrast diagram (drawn to the same scale) of engines for each vessel, and the table below shows the stress in lbs. per sq. in. on the various parts of the two engines. From this it may be seen that the stress in the case of the

TABLE IV.—Showing Stress in Lbs. Per Sq. In. on Various Parts of Main Engines for Cargo Vessel and Torpedo-Boat Destroyer.

	Cargo steamer, 3,750 I.HP., 80 revs., 7,500 I. HP. combined.	Torpedo-boat destroyer, 3,000 I.HP., 390 revs., 6,000 I. HP. combined.
	Lbs. per sq. in.	
Crank shaft	3,200	6,700
Piston rod body (tensile)	2,370	5,275
Connecting rod bolts, bottom end	5,200	8,875
Piston rod screw	4,150	9,150
H.-P. cyl. barrel at test pressure	4,175	4,400
I.-P. cyl. barrel at test pressure	3,230	4,700
L.-P. cyl. barrel at test pressure	2,580	2,230
Factor of safety: Conn. rod bolts	12	7.5⅝
Piston rod body	26.4	12.7½
Piston rod screw	13.2	7.3½
Min. tensile strength: Steel	28 tons.	30 tons.
Cast iron	8 tons.	9 tons.

destroyer is almost double so far as the crank shaft and piston rod are concerned. A destroyer is an instrument of warfare where everything is subservient to the one dominant desideratum—high speed, and the risks run in a naval fight will not be associated only with the machinery.

TYPICAL ENGINES ILLUSTRATIVE OF GENERAL PRACTICE.—In Figs. 17 to 27 there are reproduced drawings of various types of engines to illustrate the general practice so far as the arrangement of cylinders, valves, working parts and framing are concerned. Two steamers successively built for the service of the Lancaster & Yorkshire and London & Northwestern Ry. companies between Fleetwood and Belfast serve to show in what direction changes have been made in channel steamer practice. The "Duke of Lancaster" was built in 1894 and the "Duke of Cornwall" in 1898. They are practically identical ships,



Figs. 4 to 7. Joints for High Pressure Steam and Feed Pipes.

and the engines of the former are illustrated in Figs. 17 and 18, and the engines of the latter in Figs. 19 and 20. It was stipulated that there should be a large reserve of power in order that a voyage ordinarily completed in 6½ hrs. might be accelerated to 5½ hrs. to "catch the tide." Both have twin screws. The earlier boat was fitted with three crank triple expansion engines,

$$\frac{24 - 36 - 55 \text{ ins.}}{33 \text{ ins.}} \times 160 \text{ lbs.},$$

developing 5,400 I. HP., at 150 revolutions. The later boat has four crank triple expansion engines

$$\frac{22\frac{1}{2} - 34 - 38\frac{1}{2} - 38\frac{1}{2} \text{ ins.}}{33 \text{ ins.}} \times 180 \text{ lbs.},$$

indicating about 5,700 I. HP. at 160 revolutions. The rise in boiler pressure will be noticed, and the increase in revolutions and consequently of piston speed. The latter engine is arranged on the Yarrow-Schlick-Tweedy balancing system.

A similar comparison between two cargo steamers may be suggested by reference to the S. S. "Volta," completed in 1892, and S. S. "Sokoto," constructed quite recently; both are for the same owners, and work in the same trade, and the engines of the "Sokoto" are illustrated in Fig. 21. The "Volta" has single screw, triple expansion engines,

$$\frac{23 - 38 - 61 \text{ ins.}}{42 \text{ ins.}} \times 160 \text{ lbs.},$$

the power being 1,400 I. HP. at 70 revolutions, the specified piston speed being 500 ft. per min. The "Sokoto's" engines are

$$\frac{23 - 38 - 63 \text{ ins.}}{45 \text{ ins.}} \times 180 \text{ lbs.},$$

single screw, the power being 1,800 I. HP. at 85 revolutions, the piston speed thus equalling 650 ft. per minute. The only other notable changes are the addition of a feed-heater to the later boat and the substitution of a propeller having cast-steel boss and bronze blades for the cast-iron propeller used in the earlier ship.

The S. S. "Ortona," built in 1898 for the Pacific Steam Navigation Co., may be considered as an example of present day shipbuilding and marine engineering, as she is intended to maintain an all round fairly high ocean speed on one of the longest voyages in the world, carrying a good paying cargo (proportionally much greater than that carried by fast Atlantic liners) in addition to a large number of passengers of all classes. Such considerations as these put a limit on the speed at which voyages may be economically made. The cylinders of the "Ortona's" engines, Fig. 22 and 23, are 30 ins., 50 ins., 83 ins. diameter, by 54-in. stroke, and on trial the mean I. HP. was 8,550 at 81.9 revolutions.

The engines of the "King Alfred" are illustrated as typical of naval practice to-day, Figs. 24 to 27.

ENCLOSED ENGINES.—The high speed of rotation of the destroyers' engines, which run up to 420 revolutions per minute, may make it almost a necessity to adopt the closed-in system in combination with forced lubrication. The advantage of this will be appreciated when it is stated that the space between the twin sets of engines in most of the destroyers does not exceed 3½ ft., the starting platforms being as a rule at the forward end. Any doubt entertained as to the practicability of carrying out the system in destroyers of 30 knots speed has been dissipated by the success of one of the British boats, which is working satisfactorily with closed engines and forced lubrication. The new arrangement, however, calls for a greater faith on the part of the engineer in charge, who is not able to see at all times the condition of nuts and pins.

AUXILIARY MACHINERY: PISTON PACKING.—The increase in steam pressures has involved several problems in connection with the auxiliary machinery on board ship. In some of the early high pressure naval machinery there was considerable leakage in the auxiliary as well as main engines through piston and slide-rod glands having asbestos packing. In one case a packing was substituted consisting of powdered white metal, black lead and mineral grease mixed together and held in position in the glands or stuffing box by vulcanite rings inserted at top and bottom. It proved efficient and even in the case of some of the main engine glands, this same packing was substituted for asbestos, the ordinary metallic packing being retained in the upper gland; but here the retaining rings were of metal instead of vulcanite, and there was no leakage during the two years of the use of this packing in the lower gland of the high pressure cylinder of an engine when working at all powers from 2,000 to 12,000 HP. In the case of an engine running a dynamo the tightness was of corresponding duration. A development

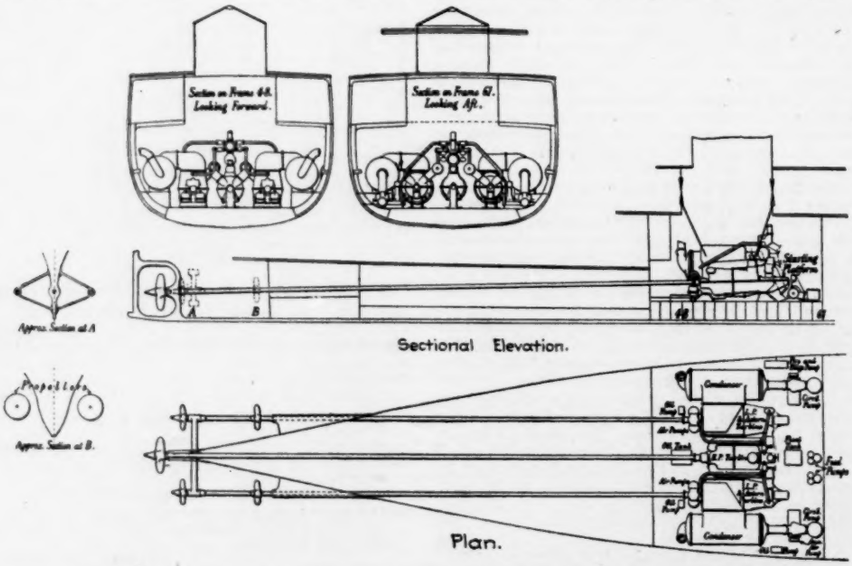
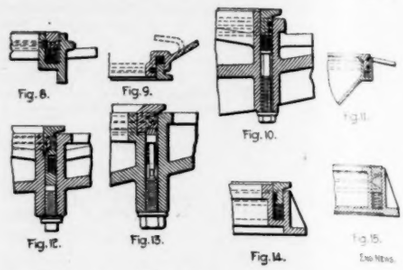


FIG. 28. ARRANGEMENT OF TURBINE MACHINERY FOR PROPOSED STEAMER OF 7,000 I. HP.

in the opposite direction has recently taken place, it having been found that, under usual circumstances metallic packing is unnecessary for the piston and slide rods of the low-pressure cylinder. Soft packing in these positions behaves satisfactorily and does not require the skill in attention and overhaul that many metallic systems involve. In the navy most low-pressure glands are now being fitted with soft non-metallic packing.

The question of the coal consumption of auxiliary machinery has occupied much attention. There can be no doubt that a saving could be effected by compounding many of the engines, but in naval ships, least, the necessary increase in weight is an objection. Flat slide-valves, with relief rings at the back wh[ere] necessary, should replace piston slide-valves. Nearly [all] the piston slide valves in the auxiliary machinery of n[aval] ships, at all events, have, until recently, been solid, although they may be tight when new they soon wear, [with] the result that constant leakage to the conden[ser] goes on. Where such piston valves require to be fi[tted] they are now supplied with "restricted expansion" ri[ngs] similar to those fitted to the main pistons.

The close exhaust system of dealing with e[xhaust] steam from auxiliary machinery, introduced by Sir John Durston, consists in connecting the auxiliary ex[haust] mains to the evaporator steam coils, and to the L.P. cylinder chests of the main engines through suitable [stop] valves.



Figs. 8 to 15. Relief Rings for Intermediate Pressure and Low Pressure Slide Valves.

The direct connections to the auxiliary condensers are kept closed by spring loaded valves set to lift when the pressure in exhaust pipes rises above a desired amount. Sentinel valves are fitted and set to blow off at 30 lbs. (above atmosphere). The result of this arrangement is that the condensers only receive such steam as the evaporators cannot condense in their heating coils. The connections to the L.-P. chests when opened allow the exhaust of the auxiliaries to be used in the L.-P. cylinders. The auxiliaries have to work against a higher back pressure, but as they are at most two-stage compound engines, this leaves them perhaps as large a range as is desirable, and steadies their running. The great advantage of the system is that it allows the latent heat of the exhaust steam to be usefully employed, instead of passing to the condenser.

It has been suggested that much of the auxiliary machinery should be operated by electricity, and it seems probable that where extensive use is made of the current, admitting of an economical system of generation, good results might accrue, especially in the driving of fans and other gear situated at present at considerable distance from the main steam leads. But the experience of some of the superintending engineers and also of the United States naval authorities, who have tried the electrical system, "has not been altogether favorable." One difficulty to be guarded against is the application to such mechanism as requires a great initial impulse—as in the case of anchor gear, for instance, where the steam stored up overcomes a sudden and heavy load. There are reasons also for not adopting electric drive for any of the auxiliaries upon which the main engines are directly dependent. In the case of some of the auxiliaries, too, the efficiency must be the first consideration apart from economy.

DIRECT-ACTING VS. CRANK PUMPS.—In this connection, some results of trials made with crank shafts and direct-acting pumps, show that the steam consumption of the crank-shaft pump, both when working high pressure and compound, is much higher than with the direct-acting pump, the steam consumption for the simple working being 67.8 lbs. as against a mean of about 48 lbs., whereas with compounding the difference is equally marked, and the mechanical efficiency is quite 10% better with the direct-acting pumps.

THE PROPELLER.—Turning now to speed attained with steamships, it can scarcely be said that appreciable progress has been made in connection with the solution of the propeller problems; but the length of this paper already precludes any discussion here of the subject. There is a growing tendency in favor of twin screws, largely because of the security they afford against complete breakdown, and something like 5.5% of all steamers now constructed are of this type. Triple screws have been adopted for one or two merchant vessels for shallow river service, three-cylinder engines on the triple compound system being fitted athwart the ship with cranks running fore and aft, each driving a separate screw, and connected by a coupling rod at the forward end of each crank. This arrangement secured the advantage of triple expansion, and enabled the screws to be of less diameter than would have been the case with single or twin propellers. These instances, however, are exceptional. In naval practice there are several applications of triple screw propulsion, each screw having an independent engine. This system, however, was adopted not so much because it increased the propulsive efficiency—it is very

doubtful if such is the case—but because it enabled the center engine and screw to be alone used for comparatively low speed, with the two side screws running idle so as to reduce the consumption at cruising speed; but it is possible that this may be achieved by other means, especially if the three propellers are found to reduce the propulsive efficiency.

It may be incidentally mentioned that, to achieve the same result, an engine was built some years ago, in which a fourth or "additional" cylinder was introduced to act as a first-stage cylinder or to be idle as the conditions suggested. The cylinder had all the necessary connecting pipes, passages, links and valves, but when the engine was working at full power, the piston of the added cylinder was retained in equilibrium, the steam passing to the second-stage cylinder, where it worked at its initial or full pressure. When steaming at low power the extra cylinder came into operation, and thus there were four stages of expansion. This system was fitted to a Russian volunteer ship, the "Queen Olga," but the vessel has been continuously worked at full power, so that there

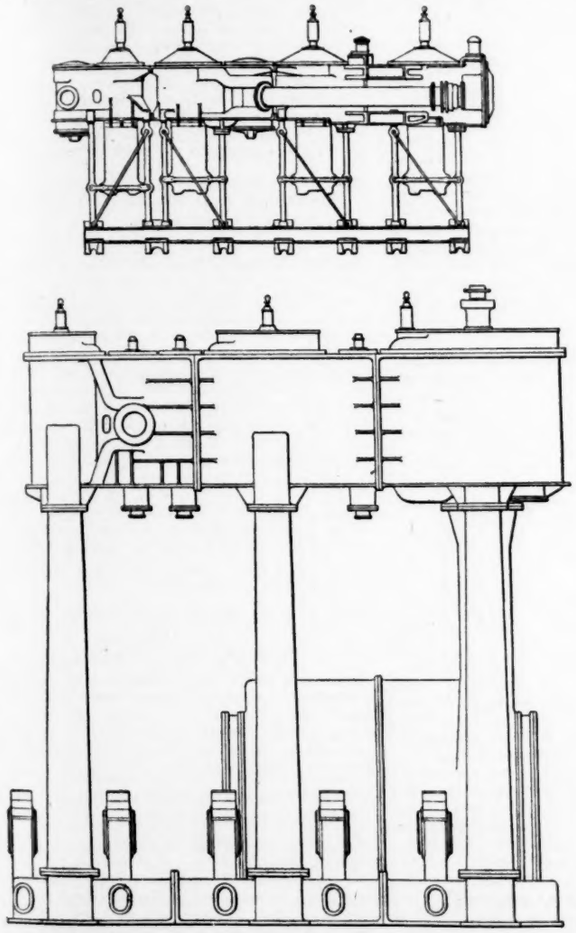


FIG. 16. COMPARATIVE DIMENSIONS OF TORPEDO BOAT AND MERCHANT VESSEL ENGINES OF 3,000 I. HP.

that attained by the City of Dublin Steam Packet Co.'s steamers on the cross-channel run—23.62 knots with steam of 171 lbs. pressure, the power being 8,500. These vessels, of 3,096 tons builders' measurement, have four-cylinder triple expansion engines, with four double-ended boilers worked on the closed stoke-hold system.

A COMPARISON OF HIGH-SPEED STEAMING—WEIGHTS AND SPACE OCCUPIED.—In a comparison of typical ships of to-day, including the two fastest Atlantic merchant vessels—the "Deutschland" and "Kaiser Wilhelm der Grosse"; the fastest armored cruiser—H.M.S. "King Alfred;" the largest ship ever built—the "Celtic;" a typical Channel steamer with a cruiser of corresponding size, and, finally, a typical moderate-sized merchantman, there are several points of interest, but attention need only be called to one or two. The "Deutschland" is fitted with Howden's system of draft, the "Kaiser Wilhelm der Grosse" has an open stoke-hold with natural draft, and the "King Alfred" is fitted with the Belleville boilers; and here also we have a comparison between merchant and naval practice. The naval engineer has not only less

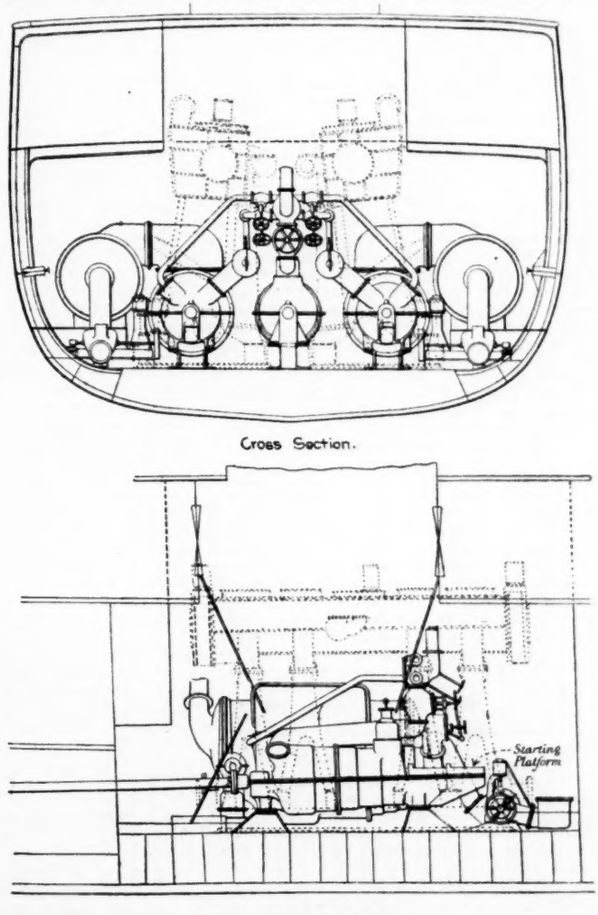


FIG. 29. COMPARISON BETWEEN SPACE OCCUPIED BY STEAM TURBINES AND RECIPROCATING ENGINES OF 7,000 HP. FOR CHANNEL SERVICE.

vantage of a higher piston speed, with lighter engine and boiler scantlings, and therefore gets 10.88 I. HP. per ton of machinery as compared with 9 I.HP. in the case of the Channel steamer.

As to the weights of machinery, it may be interesting here to compare these with those of 10 and 20 years ago. In 1881, the average for merchant ships was recorded as 4.66 I. HP. per ton, while in 1891 the average for cargo boats was 4.8, and now about 4.4. For the fastest liner the weight ten years ago was about the same as it is now —6.7 I. HP. per ton, but generally there is now more boiler power and additional weight in the machinery. In Channel steamer work there has been an increase in the power per ton of machinery. In naval practice there has been a marked diminution in weight, the rate in 1881 being 6¼ I. HP. per ton of machinery, in 1891 10 I. HP., and now 12 I. HP., all for natural draft.

A comparison of the space occupied by machinery in the latest built naval ships with cylindrical boilers, in the modern water-tube boiler war vessels, and in various types of merchantmen, including the high-speed Atlantic liner,

are no data as to the actual economy under the varying speeds of naval manoeuvring.

STEAMSHIP SPEEDS.—In the ten years considerable progress has been made in the direction of speed. In 1891 there were only 8 vessels whose speed exceeded 20 knots, now there are 58. The vessels between 19 and 19½ knots speed have doubled, numbering now 34; and Great Britain, it is interesting to note, holds a high position, due in part to the number of high-speed Channel steamers in the Irish Sea, North Sea and English Channel. The French, Belgian and Holland high-speed steamers are principally Channel boats, but the five German vessels and the four of the United States are ocean liners. The highest speed attained ten years ago was 25 knots, recorded for a British-built Brazilian torpedo boat, the fastest British torpedo boat being 22½ knots, now the record is held by the steam turbine-propelled destroyer "Viper," of His Majesty's Navy, which has attained a maximum of 37.113 knots, and a mean for one hour of 36.581 knots. The highest ocean speed ten years ago was 20.7 knots by the "Paris" and "New York"; to-day the highest speed on an ocean run has been achieved by the German liner "Deutschland," which has maintained an average of 23.51 knots, while the best speed got with Channel steamers is

space, but less weight, given him, the power per ton of machinery being almost double that in the correspondingly fast liners, while the superficial area occupied by the engine and boiler space per unit of power is about 25% less. The ratio of heating to grate area is 39 in Howden's system, 32 in the open stoke-hold system, and 31 in the Belleville boiler system. The comparison may be completed by a statement that in the case of the "New York" and "Paris," which were the fastest Atlantic vessels ten years ago, the power per ton of machinery was 6.75 I. HP. —about the same as in the present day Atlantic liners; the superficial area of machinery space 0.54 sq. ft. per I. HP., rather more than in the modern liner, and the ratio with the closed stoke-hold system of forced draft 38 sq. ft. of heating surface per sq. ft. of grate. Alike in the moderate-sized cargo steamer "Indrani" and in the "Celtic" the power per ton of machinery is about 50% less than in high-speed Atlantic liner practice, while the space occupied per unit of power is about double. A comparison of the Channel steamer "Duke of Cornwall," and His Majesty's second-class cruiser "Juno" or "Doris" is the more interesting, as both vessels have cylindrical boilers, and work with a closed stoke-hold. Here the naval ship, although working with a lower steam-pressure, has the advantage

"Kaiser Wilhelm der Grosse," "Deutschland," and "Campania," the immense cargo carrier, "Celtic," the Channel steamer "Duke of Cornwall," and the general trader, "Indrani," shows that the Atlantic liners, with cylindrical boilers, require fractionally more stoke-hold floor space per unit of power than the Belleville boiler ships, the average being about 0.28 sq. ft., as compared with 0.25, while the cylindrical boiler warship required 0.35. In the case of the "Pelorus," which is fitted with the small tube express water-tube boiler, the space occupied is highest, being 0.384. Turning to engine-room space, there is considerable variation, and it is to be noted that in the two latest classes of cruiser there has been a material reduction (0.11 sq. ft.), although the "Campania," with her five cylinders and three cranks, comes out at a very low rate. But it should be remembered that whereas in the merchant ship there is no limit to the height of the engine, in warships the necessity for protection makes tandem cylinders impossible. The space occupied per unit of power in Atlantic liners is certainly satisfactory. Here there must be a great pressure put upon the designer to economize space, because of the great value of the area of the various decks; the average revenue per square foot of deck, excluding only engines and boiler spaces and up-

takes, in one of the latest liners on the various decks is as follows:

	Per sq. ft. Summer.	Per sq. ft. Winter.
Promenade	7s. 6d.	4s. 11d.
Upper	5s. 10d.	4s. 2d.
Main	4s. 2d.	2s. 4d.
Lower	4s. 3d.	2s. 4d.

When it is noted that this particular ship makes from 12 to 15 round voyages in the year, it will be recognized that every square foot which the engine designer saves on the four decks indicated, ensures a possible yearly addition to the passenger earnings of £20, without any appreciable increase to expenses.

THE STEAM TURBINE.—Any review of marine engineering progress would be incomplete without a reference to the possibilities of propulsion by steam turbines; but at the end of a paper already too long, only a casual reference to the subject is possible. In electric-light work, the steam turbine has become a most efficient motor, and exhaustive trials have demonstrated its economy in steam consumption, the actual rate of a 1,000-K-W. set having been 9.19 kilos per K-W.-hour, which may be accepted as equalling about 12½ lbs. per HP.-hour. In the case of a long distance sea voyage at a uniform speed, and this is the condition prevailing in 99% of merchant steamers, there can be no doubt of the economy of the turbine. In such case, it can be designed for the maximum load, which would be the average working load. For naval work, where the speed is variable, the same advantages may not accrue, because the steam losses are practically constant irrespective of the power being developed. Where weight is a primary factor, even this need not militate against its adoption, and thus it would seem as if the future would see a great development in this direction. Fig. 28 illustrates the design for a turbine-driven steamer of 7,000 HP. with three shafts, two of which are driven by low-pressure turbines, while the center shaft motor is of the high-pressure type. The turbines for driving the ship astern are incorporated with the low-pressure system, being fitted in the exhaust casings with a valve to pass the steam direct from the boiler to the astern turbines, in which case the low-pressure ahead turbines on the same shaft rotate in a vacuum. At the same time, the steam is cut off from the high-pressure turbine which also runs idle in a vacuum. It will thus be seen that for driving ahead the steam passes through the high-pressure turbine, thence through self-closing valves to the two low-pressure turbines, and finally to the condenser; but should the order be given to reverse the engines, the main admission valve is closed, and the steam is then passed through other valves to the two astern turbines, which being of large area develop considerable power and speed sternwards. The self-closing valves prevent the steam passing to the H.-P. motor. The change is easily made as all the valves are actuated from the same platform, and the arrangement is such that either of the side propellers may be driven ahead or astern separately. As to the relative space occupied the sections, Fig. 29, show the difference at a glance, and the weight and space occupied for turbine machinery and reciprocating engines of 7,000 I. HP. are as follows:

	Reciprocating engines.	Turbine machinery.
W't in eng. rooms and funnel..	270 tons.	190 tons.
Floor space	911 sq. ft.	911 sq. ft.
Capacity required by engines..	14,430 cu. ft.	10,500 cu. ft.

The success of the Parsons turbine has brought several others into the field, and although experiments have been made at Barrow-in-Furness with several of these, they are not sufficiently advanced or conclusive to enable results to be given here. The season's work of the turbine-driven steamer "King Edward," built on the Clyde, will also yield most important data.

SUMMARY OF RESULTS.—Steam pressures have been increased in the merchant marine from 158 lbs. to 197 lbs. per sq. in., the maximum attained being 267 lbs. per sq. in., and 300 lbs. in the naval service. The piston speed of mercantile machinery has gone up from 529 to 654 ft. per minute, the maximum in merchant practice being about 900 ft., and in naval practice 960 ft. for large engines, and 1,300 ft. in torpedo-boat destroyers. Boilers also yield a greater power for a given surface, and thus the average power per ton of machinery has gone up from an average of 6 to about 7 I. HP. per ton of machinery. The net result in respect of speed is that while ten years ago the highest sustained ocean speed was 20.7 knots, it is now 23.38 knots; the highest speed for large warships was 22 knots and is now 23 knots on a trial of double the duration of those of ten years ago; the maximum speed attained by any craft was 25 knots, as compared with 36.581 knots now, while the number of ships of over 20 knots was 8 in 1891, and is 58 now. But probably the result of most importance, because affecting every type of ship, from the tramp to the grayhound, is the reduction in the coal consumption. Ten years ago the rate for ocean voyages was 1.75 lbs. per HP. per hour; to-day in the most modern ships, it is about 1.5 lbs. Ten years ago one ton of cargo was carried 100 miles for 10 lbs. of fuel, whereas now, with the great increase in the size of ships and other mechanical improvements, the same work is done for about 4 lbs. of coal—a result which means a very great saving when applied to the immense fleet of over-sea carriers throughtout the world.

ANNUAL CONVENTION OF THE LEAGUE OF AMERICAN MUNICIPALITIES.

The fifth annual convention of this organization was held at Jamestown, N. Y., Aug. 21 to 24. The opening session was devoted to the usual addresses of welcome and routine business. The president, Mr. J. A. Johnson, Mayor of Fargo, N. D., stated in the course of his address that the league is the only organization which covers the whole range of municipal administration. He thought that the league had already saved the cities of the country millions of dollars in the cost of paving and lighting alone.

The report of the secretary, Mr. John MacVicar, of Des Moines, Ia., stated that a good part of the nine months since the last meeting has been devoted to an attempt to disentangle the financial affairs of the league. There remain some $2,300 of unpaid dues. The bureau of information has answered many inquiries, but it has never been properly organized. The report of the treasurer, Mr. Thos. Taylor, Bridgeport, Conn., showed a balance of $454.

SPECIAL ASSESSMENTS FOR CITY WORK.

By Jas. L. Weeks, City Attorney, Jamestown, N. Y.

The author reviewed a number of cases involving assessments for street and sewer work which have been decided within the last three years by federal and state courts. The first of these was Norwood (O.) vs. Baker, decided by the U. S. Supreme Court in 1898. The court held that the assessment in question was void because it burdened one piece of property with the total cost of the improvement, regardless of benefit. This was at first thought by many to be equivalent to a declaration of the invalidity of the frontage assessment plan, but subsequent decisions by the courts of seven states, and finally, in October, 1900, by the U. S. Supreme Court itself, have established the general principle that assessments for benefits are legitimate, regardless of the particular method employed, so long as the actual benefit is not exceeded.

GARBAGE DISPOSAL.

A paper on "The Unsatisfactory Condition of Garbage Disposal in the United States" was read by Mr. M. N. Baker, of the editorial staff of this journal. It was published in our last issue. A paper dealing with garbage collection and disposal at Grand Rapids, Mich., was read by Dr. Wm. De Lano, of the health department of that city. The garbage is collected by a contractor, who is licensed by the city. He is not allowed to charge more than 10 cts. a week for house service nor more than $1 a week to hotels. The frequency of collection is regulated by the board of health. The garbage is collected in the cans in which it is accumulated. The cans are all washed and sterilized before they are brought back to the houses. The collectors start out with a load of empty clean cans, numbered in accordance with the route. A clean can is left wherever one containing garbage is removed. This plan has been in operation for three years.

The garbage is burned in a double Engle furnace, having a total capacity of 100 tons a day. The total amount burned in 1900 was approximately 11,000 tons, and the cost for fuel and labor averaged 34 cts. per ton. Four men are employed at the furnace. One of these cleans out the furnace at night, preparatory for the work of the following day. Coal costs $3 per ton. In 1900 one ton of coal was burned for each 22 tons of garbage. Each 25 tons of garbage yields one ton of ashes. Analyses have shown that the ashes contain valuable fertilizing material. It is believed that a market for them might be developed. There was no discussion on these papers, nor on any of the four presented at the session on Wednesday afternoon.

THE VALUE OF MUNICIPAL LEAGUES.

By Wm. A. Crandall, New York city.

The author proposed an amalgamation, or preferably a federation, of the national societies devoted to municipal affairs. A congress of such bodies might be made the basis of a summer school of municipal economics.

THE PROPOSED OHIO MUNICIPAL CODE.

By Edward Kibler, Newark, O.

This proposed code, like the Municipal Program of the National Municipal League, has been outlined in previous issues of this journal. Its four main features are: (1) Local self-government through the divorce of state and local functions. (2) The separation of the legislature and administrative powers of city government. (3) Civil service. (4) Non-partisan elections. This code passed one branch of the Ohio legislature on a non-partisan vote, but was recalled and defeated by a partisan vote. At a meeting of the Ohio State Bar Association, in July, 1901, it was voted to recommend the adoption of the code, with amendments curtailing the provisions for an extension of municipal ownership. It is expected that a bill including the code will be introduced in the legislature next January.

COST AND DURABILITY OF BRICK PAVEMENTS IN ITHACA, N. Y.

By Prof. C. L. Crandall, Ithaca, N. Y.

During the last nine years paving work costing in the aggregate about $390,000 has been executed at Ithaca. The bulk of the expenditure has been for brick pavements, but Medina sandstone and wood have also been used.

Most of the brick has been laid on 6 ins. of concrete, with a 2-in. sand cushion. Rosendale cement has been used, mixed with two parts of sand, then rammed with broken stone. Asphaltic cement filler was first employed, but this soon gave place to a sand filler. This change effects a saving of 10 cts. per sq. yd. in first cost. Excluding excavation and sundries, the cost of brick paving has decreased from $2.44 per sq. yd. in 1892 to $1.44 in later years. If excavation and sundries are included the cost has been from $2.65 to $1.68. In 1900 the day labor plan was adopted, with the result of an increase in cost of 20 cts. per sq. yd.

In the latter part of July, 1901, records of traffic on three streets were kept for the hours from 5 a. m. to 10 p. m. The classification used was that adopted by the Road Inquiry Division of the Department of Agriculture. The average total traffic on the three streets for the 21 hours per day was 550, 886 and 924 vehicles respectively. During one day a count of bicycles was made on one of these streets. It was found that 1,380 wheels went by the point of observation, which was over 40% more than the number of ordinary vehicles observed for the same day.

On streets which have had seven to nine years' use the brick is about half worn out. It has been found that, except in frosty weather, brick can be used without trouble from slipperiness on grades up to 9%.

THE DEVELOPMENT OF BITUMINOUS PAVEMENT, EMBRACING THE USE OF COAL TAR AND ASPHALT IN STREET WORK.

By Fred. J. Warren, Boston, Mass.

This paper opened with an historical account of the early use of asphalt pavement in Europe and America. It dealt with some of the difficulties of so proportioning the bituminous cementing materials and the sand or other strictly mineral matters as to prevent running in warm weather and cracking in cold weather. In conclusion, the author advocated the substitution of much coarser grained material for the sand and powdered limestone used in sheet asphalt work. He suggested 60 parts by weight of broken stone, 2 ins. in diameter, the voids of which should be filled with graded material until the remaining voids are reduced to 9 or 10%. This space would be filled with coal tar. By using the larger stone greater rigidity could be secured, while at the same time employing a softer grade of bituminous cement. A plant for preparing this sort of paving material would be cheaper than one for the preparation of asphalt. New Bedford, Mass., is now considering the establishment of a municipal bituminous macadam plant.

STEEL AND CONCRETE CONSTRUCTION IN MUNICIPAL WORK.

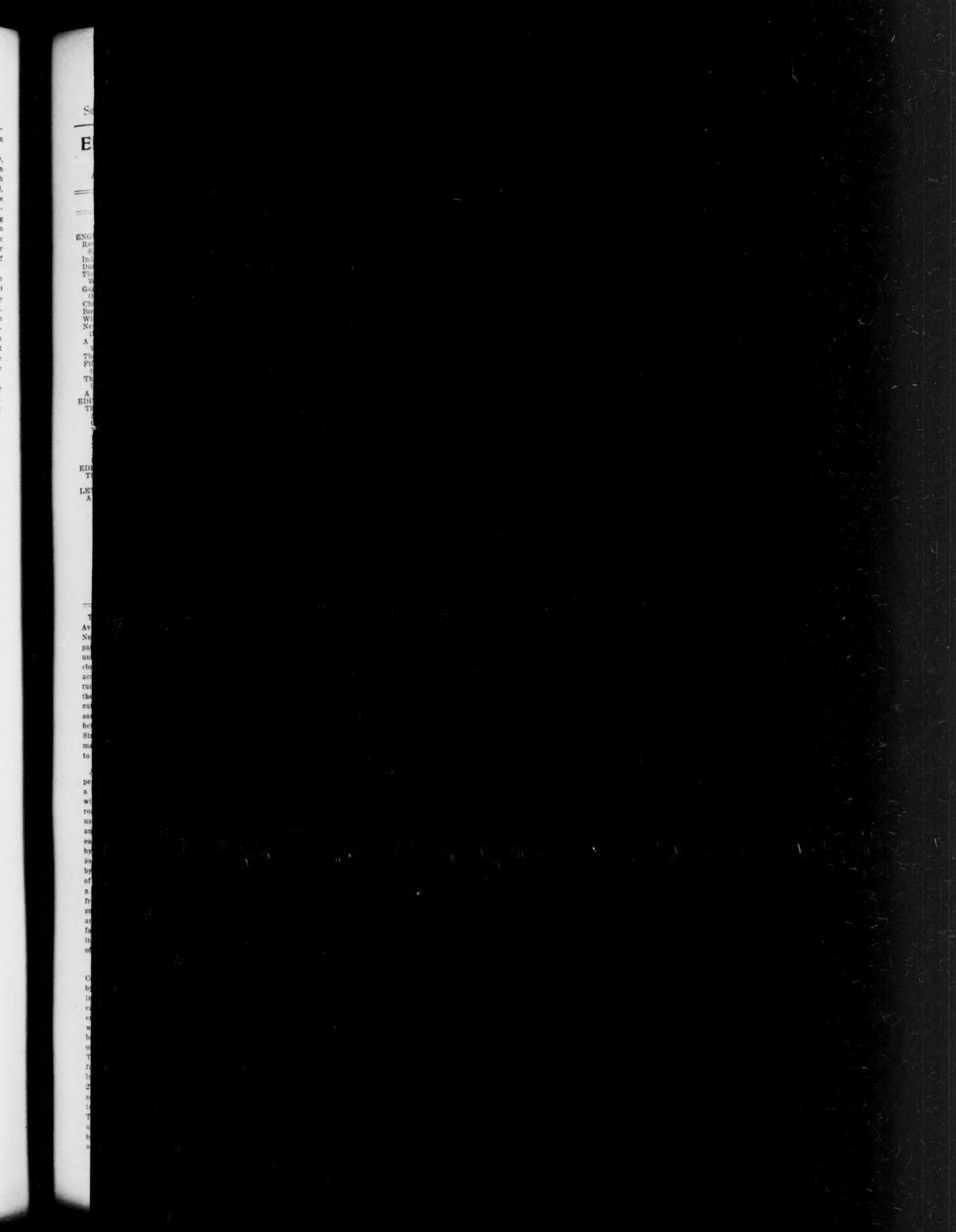
By Merrill Watson, New York city.

This was a popular paper, illustrated by lantern slides, designed chiefly to show the applicability of a combination of expanded metal and concrete. The lantern slides showed a large number and variety of instances of this combination, including paving foundations, sewers, bridges, fountains, tanks and reservoirs.

PUBLIC OWNERSHIP OF PUBLIC UTILITIES.

By Lee Meriwether, St. Louis, Mo.

The author grouped his paper around three objections commonly made to municipal ownership, giving his reasons for believing that public ownership is not revolutionary and experimental, not more expensive, all things considered, than private ownership, nor more likely to lead to political corruption. As to the latter, he maintained that public service corporations are in politics and that they give positions at the suggestion of municipal officials. Both the paper and the discussion which followed it related quite extensively to the public ownership of steam railways. A number of statements, pro and con, were made regarding the service of the European state railways, but on the whole the remarks were not complimentary to the service. Mr. J. A. Johnson, president of the league, gave some figures which he had gathered while abroad as to the profits of municipal ownership in Glasgow and Amsterdam. In Glasgow the street railway profits for one year were over $200,000, and from this and other municipal enterprises an aggregate net profit of about $700,000 was secured. The municipal telephones of Amsterdam yielded a net profit of about $50,000 in a single year.

A number of papers on the program were read by title and others were omitted entirely, through the failure of the authors to appear. A few papers were of too general a character to be noticed here.

The election of officers resulted in the choice of Mr. Chas. Ashley, Mayor of New Bedford, Mass, as president, and the re-election of Mr. John McVicar, of Des Moines, Ia., as secretary, and Thos. P. Taylor, of Bridgeport, Conn., as treasurer. The convention of 1902 will be held at Grand Rapids, Mich.